FOOD TECHNOLOGY

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March, 1956 Volume 10, Number 3

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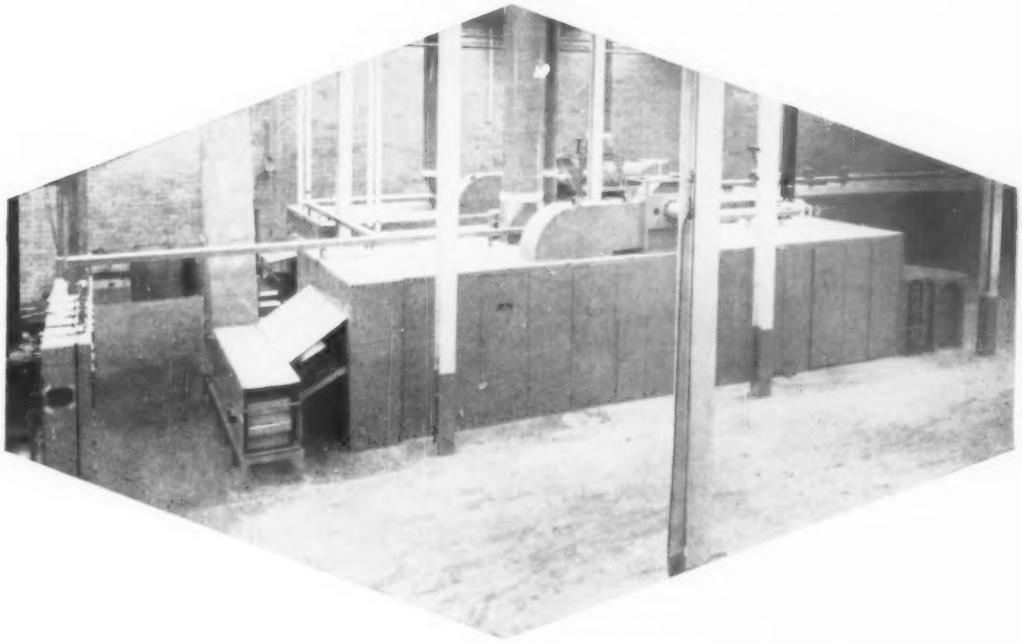

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IFT ACTIONS AND REACTIONS...

REPORT ON ANTIBIOTICS . . .

Some Highlights of the International Conference

World-wide interest in antibiotics led to the International Conference on the Use of Antibiotics, held at the U. S. Department of Agriculture in Washington. Sponsors were the National Academy of Sciences and the National Research Council. Some 400 persons from the United States and 15 other countries attended.

The October conference was called to evaluate present information on growth and other responses of livestock to low-level antibiotic feeding, antibiotics in crop production and food preservation, the influence of agricultural uses of antibiotics on antibiotic-sensitive microflora, antibiotic effects on reproduction and carcass quality in livestock, antibiotic residues in human food, mode of action of antibiotics, and discussion of problems requiring research.

While the text of the entire Conference is too lengthy for inclusion, some highlights merit the attention of food technologists, particularly the summation by Dr. Emil M. Mrak of the University of California, of the Fourth Session on Food Preservation.

As to whether there is a place for substances such as antibiotics in food processing, the answer appears to be "Yes" as they can be considered to confer a sort of chemical "pasteurization" which might be especially valuable in extending the life of fresh commodities. In this connection, application might be useful (a) between slaughter and the consumer (meat and poultry); (b) between fishing beds and shore, and thence to the consumer (fish); (c) between farm and consumer (fresh fruits and vegetables); (d) between farm and processor (fresh, packaged, and hydro-cooled fruits and vegetables); (e) to extend life of commodities in areas where refrigeration is scarce, and to permit hauling over greater distances (meat, milk); (f) possibly in bakery products containing custards and creams, some of which cannot be sold during the hot summer months, and (g) most suitably when long-term sterility is not a goal.

"What could this mean to the food processor and consumer?" To the processor it could mean reduced losses of the fresh commodity in handling, storage, and transportation, and a better processed product. However, it would require a thorough knowledge of what he was doing for the processor to achieve success. To the consumer it could mean (a) better quality and possibly lower cost of packaged meats and poultry; (b) better quality and wider distribution of fish; (c) conceivably better processed fruits and vegetables and possibly better texture, flavor, and appearance; and (d) in some cases better utility value: e.g. packaged pre-cut meats and moist-pack fruits.

Regarding "safety," the evidence is that residues are absent or insignificantly small in cooked foods; however, those eaten raw must be further examined. Therefore, treated foods must undergo rigorous tests and be cleared by official approval.

"How would antibiotics be applied?" This would vary with the commodity. The form and course of spoilage must first be understood for each product, e.g. the differences between fish and shellfish. A number of procedures has already been suggested: e.g. in ice, by spray or dip, by injection, etc. It may be advantageous to use a combination of antibiotic treatment with other forms of processing: e.g. irradiation, refrigeration, heating, etc. The last application has proved disappointing so far as reduction of can-processing is concerned.

Some pertinent questions and possible limitations of the use of antibiotics in food preservation remain to be answered. At such low concentrations as are suggested, it would seem possible to promote the growth of resistant mutants of the microorganisms being attacked. Will the results therefore vary with time and usage? More needs to be known about the encouragement of resistant strains; perhaps plant pathogens, perhaps yeasts and fungi replacing inhibited bacteria. Very little is known of the behavior of antibiotics in vastly different forms of food. What are the residues, the effectiveness, the influence on the food? What are the effects on flavor, eating quality, etc., etc.? Also, what will be the effect on the processes that rely on microorganisms as in the making of cheese, pickles, and wine?

The all-important question to be answered at this time is "Where do we stand at present?" According to Dr. Mrak's summary, it appears that the consumer stands to gain in acceptability, utility, stability, safety, and aesthetic appeal of his foods; areas lacking in refrigeration may gain in better marketing possibilities; the processor may reduce his losses, make a better quality product, lower operating costs, and achieve better transportation. The food technologist is faced with many problems and must investigate the characteristics of each form of microbial spoilage, each product, and possibly each antibiotic. And finally, the Food and Drug Administration must make a decision as to whether the use of antibiotics in food processing will be permitted.

Rigorous tests for safety will delay the use of antibiotics in food preservation until the public can be fully assured that there is no health hazard from antibiotic residues.

* * *

Agricultural Research (4:7, 1956) reported that unbelievably small amounts of antibiotics make pigs and chickens grow more and faster on less feed. This may become a major factor in agriculture everywhere, as it now is in the United States. It was reported that no effect of antibiotic feeding on reproduction has been demonstrated, but mortality in newborn animals is reduced in antibiotic-fed chickens, poults, pigs, calves, and lambs.

USDA research reported by N. R. Ellis showed that an extra pig or two per litter was weaned when the sow's diet was supplemented with an antibiotic during gestation and lactation. Tests at USDA have indicated

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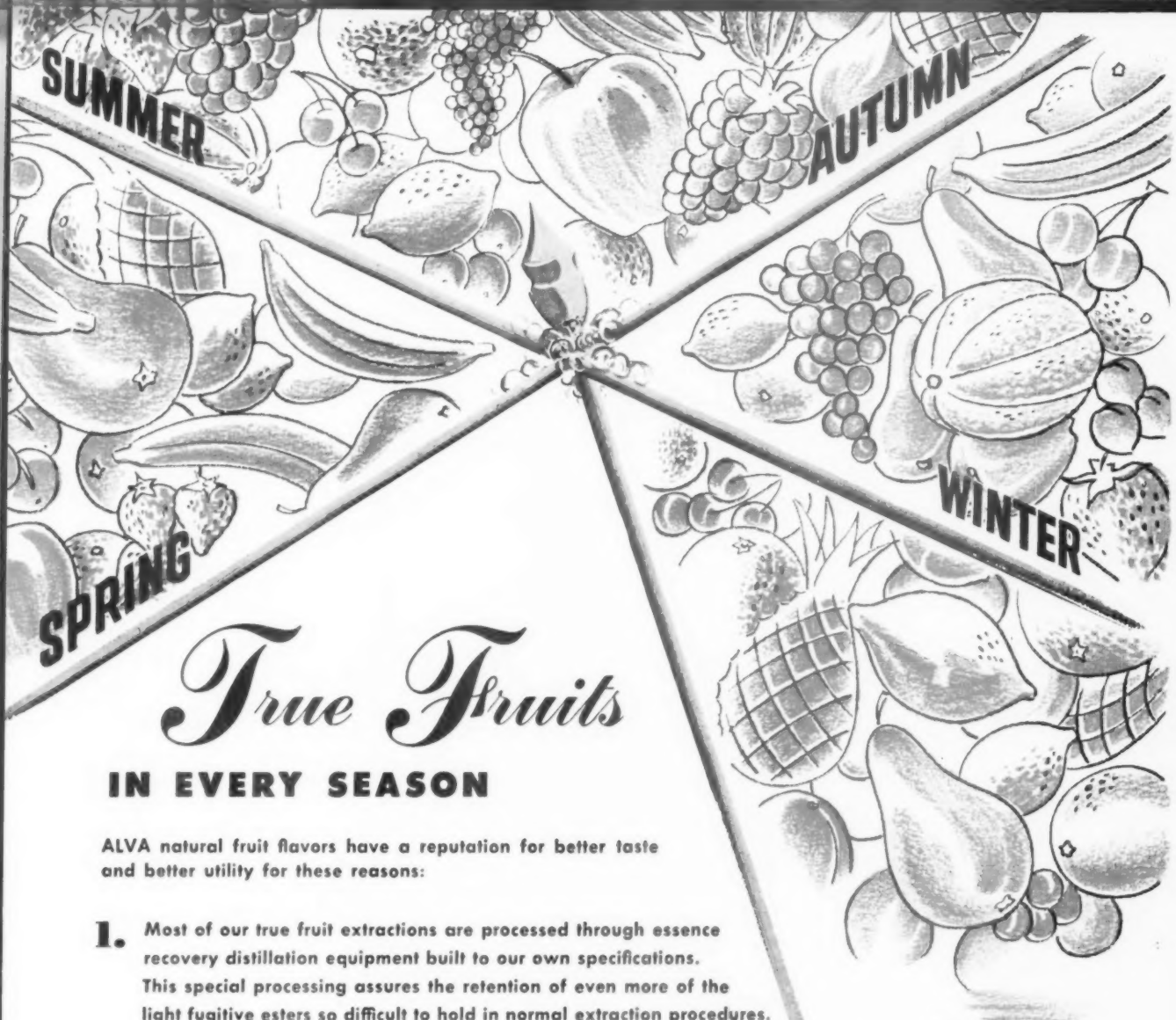

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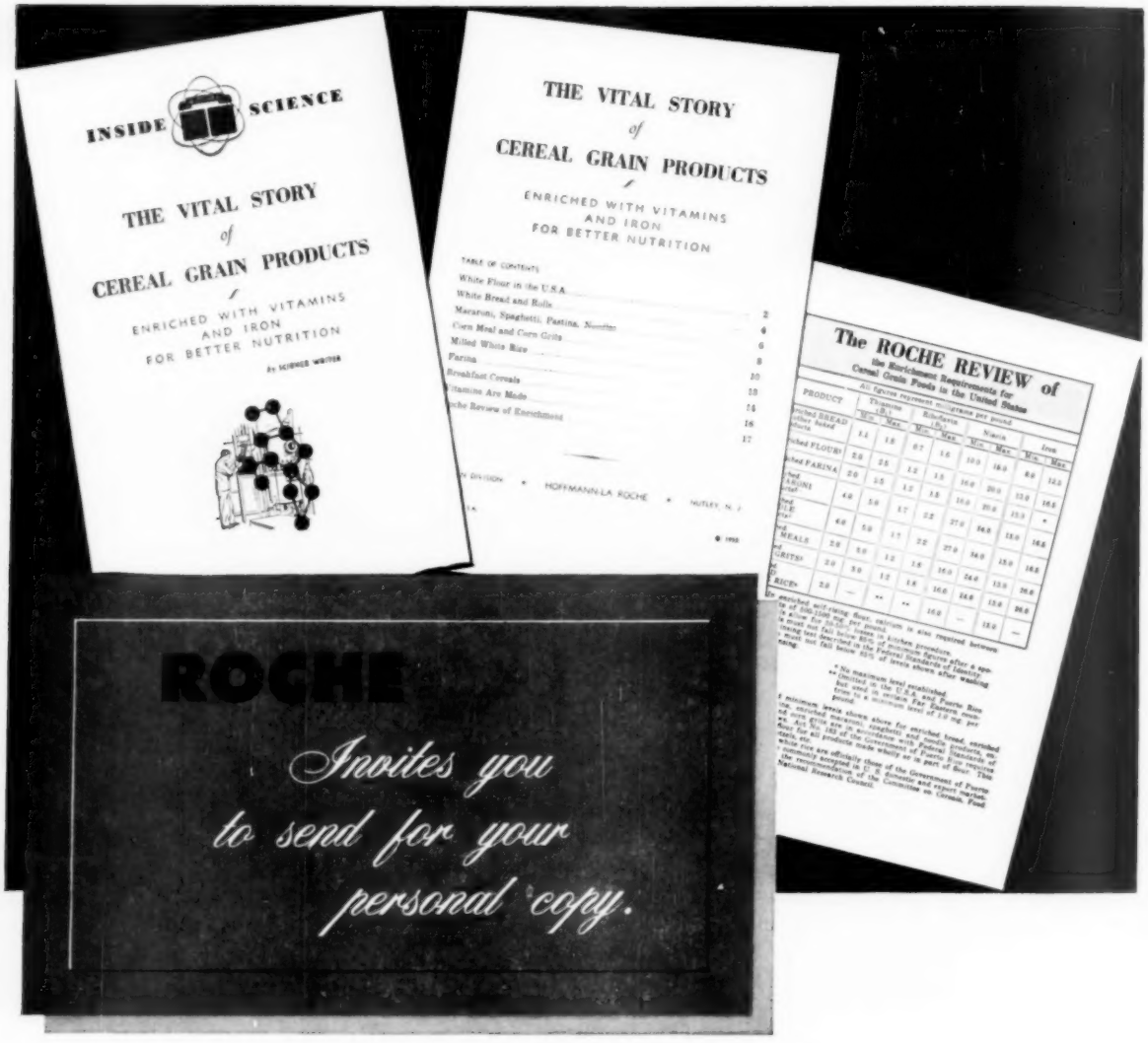

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(Continued from page 2)

some beneficial carryover effects in chicks hatched from eggs of antibiotic-fed hens and researchers now feel reasonably sure that antibiotics do no harm when fed to swine and poultry during the reproductive cycle.

H. Clausen, of Denmark, gave evidence that low-level antibiotic feeding had no adverse effect on carcass quality of swine under controlled feeding. He warned, however, that pigs allowed all the low-protein feed they would eat might become excessively fat since antibiotic feeding generally increases feed intake. Some U. S. researchers have reported that protein level may be decreased in the diet of antibiotic-fed pigs.

Emergence of tolerant or resistant bacteria requires additional research. J. J. Christensen, of the University of Minnesota, reported on variation, including many mutations, occurring in fungi grown in media containing antibiotics. Apparently no mutants have yet been found in soil microflora as a result of antibiotics that were naturally produced there.

Antibiotics may affect heredity of lower organisms such as molds and thus be helpful in genetic study.

Application of antibiotics to plants for control of many diseases was reported by W. J. Zaumeyer, of USDA. The big problem now is to find antibiotics that are effective in sufficiently low concentrations to be economical for commercial crop use.

It was generally agreed that the mode of action of antibiotics must be determined in order to make further research fully effective.

PUBLICATIONS COMMITTEE APPROVES "NEW LOOK"

At its mid-fiscal-year meeting in December one of the actions of the Publications Committee was to approve the changes in make-up that are being initiated with the present issue of FOOD TECHNOLOGY. No revolutionary departure from preceding issues has been made but sufficient modifications have been introduced to permit two new features: "IFT Actions and Reactions," a department that will utilize contributions of the recently established Public Relations Committee and "Featuring this Month . . . " a department to be devoted to depicting, over the course of a year, food laboratories, food technology departments of the colleges, experiment station laboratories, and similar interesting places where food research and development work is going on. Mrs. Anna May Schenck, member of the Public Relations Committee, will plan and edit the contributions to the "IFT Actions and Reactions" pages and J. Hamilton Kenney, Canada Department of Agriculture, Ottawa, and long active as an Associate Editor on the FOOD TECHNOLOGY board, will handle certain articles for the "Featuring this Month . . . " department. Attention is called to another innovation—the inclusion of a condensed version of an outstanding regional meeting speech.

Typographical and lay-out changes were accomplished after considerable study by the Editor, the Executive Secretary, and the Printer. The plan was then laid before the Publications Committee, which at

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Responsibility for statements appearing in FOOD TECHNOLOGY rests on the author thereof; points of view expressed in the columns of the journal do not necessarily have the endorsement of the Institute of Food Technologists. Mention of commercial products in the technical pages of this Journal is not to be construed as a recommendation of such products over others in the same category.

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its December meeting recommended its adoption beginning with the present issue.

RAY WAKEFIELD
Chairman, Publications Committee

FOOD TECHNOLOGY SHORT COURSE

The University of Missouri College of Agriculture in cooperation with Institute of Food Technology, St. Louis Section, has completed its program for the fourth annual food technology short course to be held March 16 and 17, 1956. The program, a substantial one, follows:

Friday, March 16—Memorial Student Union

8:30 A.M. Registration

9:30 A.M. Welcome—Dean J. H. Longwell, Univer- of Missouri

9:45 A.M. Panel Discussion — "Technological Problems of Food Surpluses"

Moderator: Dr. D. E. Brady, Univ. of Missouri

Economic Aspects—Mr. Gordon Nance, Univ. of Missouri

Animal Products—Mr. Clarence K. Wiesman, Armour & Company

Dairy Products—Speaker to be announced

Cereal Products — Dr. W. Dayton Maclay, Northern Utilization Research, U.S.D.A.

12:30 P.M. Luncheon—Poultry Department, Courtesy Missouri Turkey Growers and American Dairy Association

1:45 P.M. Conducted Tours — Poultry Processing Laboratories, Food and Nutrition Laboratories and Veterinary Clinics

4:00 P.M. Social Hour — St. Louis Section of IFT — Daniel Boone Hotel

7:00 P.M. Dinner — Ballroom, Memorial Student Union

"Food Production Problem in Iran"—Mr. M. J. Regan, Univ. of Missouri

Saturday, March 17—Memorial Student Union

8:30 A.M. Registration

9:30 A.M. Panel Discussion — "Automation in Food Processing"

Moderator: Dr. Frank K. Lawler, Editor, *Food Engineering*

Cereal Processing — Mr. A. F. Borer, Pillsbury Mills, Inc.

Meat and Meat Products—Wm. J. Scarlett, Minneapolis-Honeywell Co.

Dairy Operations—Dr. Dale A. Seiberling, Ohio State University

Poultry and Egg Processing—Mr. W. A. Nichols, Gordon Johnson Co.

12:30 P.M. Luncheon — Grill Room, Memorial Student Union

1:45 P.M. Panel Discussion — "Automation in Food Processing" (cont'd)

Seasonings—Dr. Roy E. Morse, Rutgers University

Fruits and Vegetables—Dr. Paul P. Wilbur, Food Machinery & Chemical Corp.

Public Health Aspects—Mr. John McCutchen, Missouri Division of Health

FOOD PHYSICS SYMPOSIUM TO OFFER UP-TO-THE-MINUTE PROGRESS

An instrument designed to develop the means of brewing a better cup of coffee, the preservation of foods by irradiation, and rapid cooking by high frequency waves, and many other advances as exciting as these will be discussed at the Food Physics Symposium, March 15 and 16 at the Plaza Hotel, San Antonio. This notable scientific conference is jointly sponsored by the Southwest Research Institute and the Institute of Food Technologists. It brings together for the first time physicists and their colleagues in related fields who are concentrating on the applications of recent discoveries to food preservation and quality control.

As a project for the Coffee Brewing Institute, Southwest Research Institute scientists are developing an instrument to analyze the vapor from coffee. They hope to establish a "flavor spectrum" which will enable them to determine the subtle differences which distinguish a good cup of coffee from a bad one. Current status of this work will be described.

The problem of sterilization of foods by ionizing radiation will come in for its share of attention at the meeting. While this form of food preservation is seen as an important phase of the industry in the future, many problems must be solved before it can be used. In the radiation process certain highly reactive chemical compounds known as "free radicals" are formed. Since these produce an undesirable taste, odor, color or nutritional changes in the food material, they must be eliminated if this new process is to prove successful. Southwest Research Institute scientists are studying these compounds by means of a newly discovered analytical technique, electron paramagnetic resonance. It is hoped the basic knowledge obtained will enable them to develop means of preventing the formation of these compounds.

Cooking by radio waves has already been demonstrated at the Institute's open house and the scientists have been studying the effects of ultrasonics upon food materials.

HEARINGS ON FOOD ADDITIVE BILLS

Congressional hearings were held from January 31st to February 3rd on pending bills to regulate the use of chemical food additives. Witnesses testified before the Health and Science Subcommittee of the House Committee on Interstate and Foreign Commerce, in behalf of various food and chemical trade associations, the packaging materials industry, labor and consumer groups. No testimony was presented by scientific, technological, or health organizations.

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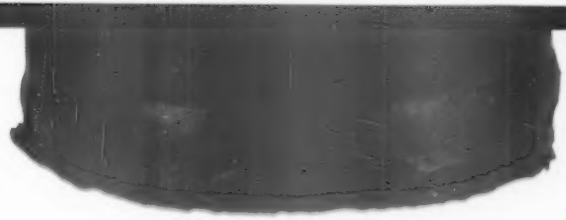

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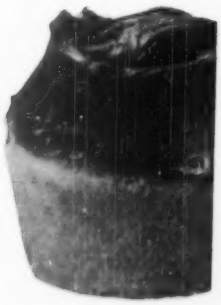

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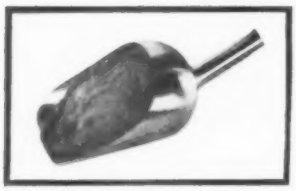

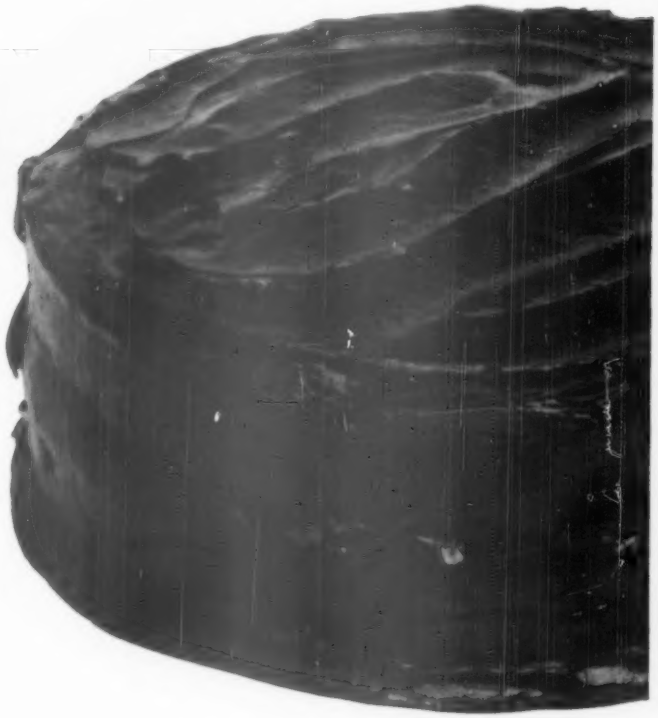

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(Continued from page 6)

The bills under consideration were H.R. 4475 introduced by Rep. J. J. Delaney, H.R. 8271 and its identical counterpart H.R. 8275 introduced by Reps. J. P. O'Hara and J. P. Priest, respectively, and H.R. 8748 introduced by Rep. Miller. These superseded several earlier bills presented during this, the 84th Congress.

Evidence of considerable behind-the-scenes effort was indicated by the almost unanimous industry support for the Priest-O'Hara bill, to which certain amendments were proposed. General acceptance of the mandatory pretesting principle had been anticipated but until now there had been divergent views on administrative procedure. Major groups in the food industry favored prior certification by FDA which the chemical industry had objected to as being a form of licensing, proposing instead that after notification of the intended use of an additive the Secretary of Health, Education, and Welfare could have the right to seek a court injunction against such use. Both industries now strongly support adoption of the Priest-O'Hara compromise proposal for prior submission of full pretesting data for the approval of the Secretary with the right for either the Secretary or the applicant to petition for a declaratory judgment in a Federal District Court to determine whether the additive has been adequately pretested and shown "safe for use under the conditions of its intended use." A food manufacturer would thus not be required to risk the penalty of violating the law by shipping food containing an additive in order to test the validity of the Secretary's refusal to approve it. Hon. John Biggs, Jr., chief judge of the 3rd Judicial Circuit, testified against submitting such highly technical issues for "de novo" trial before a lay court or jury.

The Delaney and Miller bills provide for referral of pretesting data for review by an ad hoc committee of scientific experts, upon request of either the petitioner or the Secretary. The Food and Drug Administration has no objection to such an advisory committee whose report and recommendations would not be binding upon it. Provision is also made in the Miller bill for a public hearing the record of which, including the report and testimony of the advisory committee, would be subject to judicial review by the Court of Appeals.

Testimony was presented by industry witnesses in support of a "grandfather clause" exempting additives in use before January 1, 1956. The Priest-O'Hara bill provides such exemption for authorized or approved additives (as in standardized foods, for example) whereas the Miller bill permits exemption for any previously used additive, whether approved or not, provided it presents no reasonable probability of injury to health. The Delaney bill contains no grandfather clause although a statement filed by the Food and Drug Administration accepts the limited exemption in the Priest-O'Hara bill. The Miller bill extends the scope of definition of "new food additive" to include treatments as well as substances thus encompassing radiation or other forms of processing.

Witnesses for several trade associations in the packaging industry sought exemption for substances unintentionally and adventitiously transmitted to foods via the packaging material unless a reasonable probability of injury to health existed. They objected to the requirement that substances be "generally recognized" by qualified experts to be safe for its intended use. It was contended that the qualifying word "generally" (omitted from the Miller bill) could not apply to a new substance and, moreover, it adds vagueness to the concept.

A most noteworthy feature of currently proposed legislation is that with respect to food additives, as defined, it abandons the so-called per se doctrine, under which added "poisonous or deleterious" substances are proscribed regardless of whether or not the amounts could render the foods harmful to health. Under present law, if such additives are proved to be essential or unavoidable in production, tolerances may be established after a public hearing. The Priest-O'Hara and Miller bills would permit such additives as are recognized or shown to be safe for use under the conditions of intended use, i.e. if there is no reasonable probability of injury to health when the additive is used in a specified manner and quantity, in or on a particular food or class of foods.

The industry-supported bills specify that in evaluating pretesting data for safety the Secretary shall consider "relevant health factors." The Food and Drug Administration supports the view expressed in the Delaney bill that functional value or benefit to the consuming public or in the manufacturing process shall also be considered. Industry witnesses testified that whether or not a safe additive has utility is primarily a question for the manufacturer and in any case, if it serves no useful purpose or is not desired by the consumer, economic considerations would eliminate its use. The purpose of the law, it was argued, is fundamentally to insure safety, not to regulate technological practices or consumer preferences.

Witnesses for the A.F.L.-C.I.O. and the Cooperative League supported the Delaney Bill. A statement was filed on behalf of the Food and Drug Administration but the hearing was adjourned until February 14th to hear witnesses from this agency.

NOTE: It has become possible to include an item on the February 14th hearing. Commissioner G. P. Larrick and Mr. W. W. Goodrich testified on February 14 for the F. D. A. While not opposing the liberalization of the law to permit "poisonous" additives in safe amounts, they recommended that proof of benefit to the producer or consumer be required. Arguments were advanced against a blanket grandfather clause. The declaratory judgment procedure was vigorously opposed as making de novo court trial an integral part of the process of deciding upon the safety of additives with the government bearing the burden of proof.

BERNARD L. OSER

MEMBERSHIP CERTIFICATES AVAILABLE

Engrossed membership certificates will be furnished without cost to members of the Institute who were elected to membership prior to August 1, 1955. The Council of the Institute has authorized the issuance of these certificates to all members in good standing who desire them. Members elected after August 1, 1955, have been receiving them. If you are eligible for a certificate, write to the Executive Secretary, 176 West Adams Street, Chicago 3, Illinois.

for fruit and vegetable growers... NEW HELP ON BACTERIAL BLIGHT

Recent greenhouse studies by scientists at Merck & Co. Inc., show that addition of Glycerine to streptomycin sprays increases the effect of the antibiotic against bacterial blight of beans, a disease which costs farmers millions of dollars each year.

Researchers believe the increased effectiveness of the combined spray comes from Glycerine's ability to retain moisture on leaves, and in so doing, to improve absorption of streptomycin by the plant.

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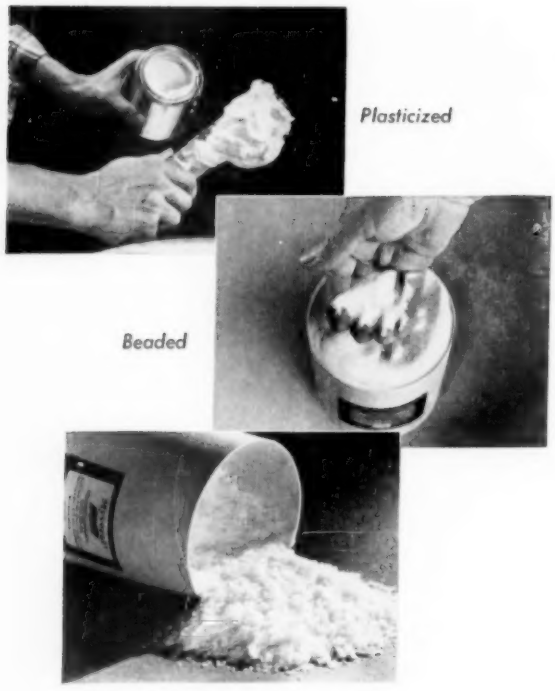

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BOOKS . . .

OFFICIAL METHODS OF ANALYSIS OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. Eighth Edition, 1955. William Horwitz, Chairman and Editor of the Editorial Board; H. J. Fisher, A. H. Robertson, and Helen Reynolds, Committee on Editing Methods of Analysis. Published by the Association of Official Agricultural Chemists, P. O. Box 540, Benjamin Franklin Station, Washington 4, D. C. and the George Banta Publishing Company, Menasha, Wisconsin.

The Association of Official Agricultural Chemists has published revised editions of its *Methods of Analysis* at five-year intervals since 1920. These volumes have been devised for the benefit and convenience of laboratory workers in analytical agricultural chemistry. The eighth edition is marked by a trend toward the increased use of instrumental methods and techniques such as chromatography. For example, gravimetric methods for vanillin and coumarin have been replaced by procedures which involve a chromatographic separation and a spectrophotometric determination; the fermentation method for thiamine has been omitted in favor of the fluorometric method. Deletions of variations in some methods have also been made in this edition in consequence of the findings of extensive collaborative studies.

Additions to this edition are too numerous to specify individually. Probably the most important addition is a new chapter on spectrographic methods covering emission techniques. Other new physical-chemical methods include a procedure for the field determination of radioactive contamination; a thermal method for determining the sterochemical composition of amphetamines; and directions for determining the optical-crystallographic properties of substances, together with tables of these properties for antihistamines, barbiturates, sulfonamides, sympathomimetic amines, and reineckates of quaternary ammonium compounds.

A wide variety of additions has been made to the chemical methods in the new edition. These include a wet digestion method for potash in fertilizers, a procedure for the determination of α-amylase in malt, and methods for stilbestrol and β-estradiol. The microchemical chapter has been expanded by including standardized methods for elemental analyses for bromine, chlorine, carbon, hydrogen, and sulfur.

An important problem facing the chemist today is the development of methods of analysis for "chemicals in foods." Needed are relatively specific and sensitive quantitative procedures. Only two such methods have been adopted by the Association during the past five years, but as more of these methods become available and are shown to be reliable through collaborative tests they will undoubtedly be added to this valuable book.

Continuing the practice followed for the last several editions, purchases of this book will be provided at cost with annual supplements containing the changes in methods as they are adopted by the Association and published in its Journal through 1959.

(Continued on page 12)

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(Continued from page 10)

In its Eighth Edition, the Association has again presented, in its *Official Methods of Analysis*, standardized analytical procedures which have been demonstrated to be reliable, which have convenient practical application, and which give reproducible results in the hands of professional analytical chemists.

J. H. MITCHELL, JR.
Chicago, Illinois

EXPERIMENTAL COOKERY, by Belle Lowe, 4th Ed. 573 pp., John Wiley & Sons, Inc., New York, 1955.

Belle Lowe's "Eperimental Cookery" is a favorite text book for advanced college courses in food preparation. It is designed to acquaint the student with the chemical and physical nature of food materials and the behavior of basic food components under conditions of food processing or preparation. The interrelationships of formula variation, mixing method and application of heat or cold are discussed. An example is the topic "egg proteins." The major protein components of egg white and yolk and their properties are first summarized. The coagulation of the egg proteins is then discussed in relation to concentration of electrolytes, pH, presence of sugar, concentration of protein, rate and extent of heating, and other processes that influence coagulation.

The subject matter is divided into fourteen chapters: The relation of cookery to colloid chemistry; Food acceptability; Sugar cookery; Frozen foods; Fruits and vegetables; Pectic substances, jelly, jam; Gelatin; Meat and Poultry; Emulsions; Milk and milk products; Eggs; Starch, flour and bread; Batters and doughs; Fats and oils.

Each chapter is followed by suggested experiments related to the topics discussed. Each experiment is a small research problem. In addition to gaining insight into food reactions, the student thus becomes acquainted with the controlled procedure necessary in carrying out research.

Professor Lowe has summarized and integrated the literature on many diverse topics,—in itself an important contribution. She has also included unpublished information from her own laboratory. Though primarily intended for use as a text, the book is useful to all who want a quick glimpse of research findings in a given field. The excellent lists of references to the literature are valuable aids to the person in research as well as to the student.

ANDREA MACKEY
Corvallis, Oregon

IFT REGIONAL SECTIONS . . .

SPEECHES, SPECIAL EVENTS, NEWS NOTES

RATIONS—Yesterday, Today, and Tomorrow*

J. D. Peterman
Colonel, QmC Commandant, Quartermaster Food and Container Institute for the Armed Forces

In modern times, as war has increased immeasurably in complexity, supplying rations to military forces engaged in global operations has followed suit. But then, here in the U. S. A., we have developed a new approach that brings to bear the best military, scientific, and technological thinking at the nation's disposal. Participating in this new and integrated approach are the National Research Council Committee on Food and the Committee on Containers of the Advisory Board on Quartermaster Research and Development, the Quartermaster Industry Advisory Committees—composed of representatives of large, medium, and small companies, the Research and Development Associates, and, within the Military, the Coordination Group, which effects liaison among the Army, Navy, and Air Force food research personnel at work on food, food preparation equipment, and feeding systems. Permit me to mention also the Quartermaster Food and Container Institute for the Armed Forces, which I have the honor to command and which is staffed by able military and civilian specialists of whom I cannot speak too highly.

All of these groups are deeply engaged in the food and container problems of today—or studying the problems anticipated for tomorrow. We shall come back to these problems of today and tomorrow. But now, for background, let us look briefly at the problems of yesterday.

The Civil War Period. Let us consider first the ration picture as seen by the Johnny Doughboy of the 1860's. The basic issue was simple—flour for bread or flapjacks, a hunk of meat, green coffee beans, salt, pepper, sugar, vinegar and dry beans. The forever-present Army bean of song and story. In view of the supranormal demand for calories in the military diet, it is not surprising that one line of thinking persists in military ration history—the daily need for bread and meat, or, in Civil War terms, "hardtack and bully beef." These are foods that stick to the ribs, through long marches, through "smoke and fire," through the cold night watch.

Another line of thinking that has come right down through the years is the hot meal—the one-hot-meal per day per man ideal. During the Civil War the hot meal was often a campfire meal, cooked and eaten in the open.

(Continued on page 14)

* Presented, with 34 slides, before the Chicago Section, January 9, 1956.

A for apple is the beginning of most primers. And apple is the first choice in flavor with most Americans, who enjoy an alphabet of apple dishes. To the distinguished family of Firmenich flavors, now enhancing many food products, is added that of Apple, captured by patient research and recreated by chemical skill. It is another Firmenich achievement, already welcomed by manufacturers who have added this popular flavor to their line of products; by others to improve those already established. Highly concentrated, stable, of the utmost fidelity and purity, Imitation Apple by Firmenich is offered with pride for your profitable use. Samples and technical data on request.

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(Continued from page 12)

Where time and the enemy permitted, Company kitchens were established in more or less substantial quarters (Figure 1).

Figure 1

Bringing Up the Supplies. Volume shipment of supplies in the Civil War was by rail and by inland water routes. Food supplies were dumped haphazardly at railheads (Figure 2). The mode of transport to rear areas and up to the lines was by means of Army wagon trains (Figure 3). The wagons carried the munitions of war. Insofar as they carried food, they were virtually mobile commissaries with cargoes of cook's kettles, Dutch ovens, barrels for obtaining water, the staple components of the ration issue, and candles and soap.

Bulk rations issued the Civil War "G. I." made no concessions to the soldier's normal desire for confections and similar appetite-appeasing foods.

To supplement their austere fare, there was the sutler, authorized vender of non-issue supplies. This worthy was a one-man post exchange—and made a good thing

Figure 2

Figure 3

of it. The saying went: you can win from a gambler now and then; from the sutler *never*.

Supplies were also brought in by forage. The line drawing (Figure 4) shows "liberated animals" being brought to camp for slaughter. If these animals are representative of the period, you can see how far we have come in the development of the beef animal. No choice cuts are in evidence in these Civil War period "critters."

Let me recall to your minds in concluding this brief account of the Civil War ration story two great industrial contributions of the era—the great impetus given the canning industry and the introduction of canned evaporated milk by Gail Borden in 1856. An early form of soluble coffee was also tried out.

Post–Civil War Military Feeding. After the Civil War military activity concentrated largely on the Western plains. The Indian Wars brought to the fore

Figure 4

the garrison way of life. It was here that the first systematized effort to improve large-group feeding began. For example, gardening was encouraged. This brought fresh vegetables into the menu. At Fort Atkinson, Nebraska Territory, 500 acres of corn, wheat, potatoes, and turnips were planted. At old Fort Laramie, now a historic shrine, the area once used as a garrison garden is still in evidence.

For the plains type of warfare attention had to be given to the utilitarian features of rations; namely, imperviousness to rough handling and weather; low space-weight characteristics; caloric density; ready use on expeditions; organized and flexible re-supply. Despite awareness of this excellent "rationale for rations," notable studies suggesting improvement by Army physicians, and the innovations—garden-fresh vegetables, for example—the basic ration of the post–Civil War period did not greatly change. The flour, the hunk of beef, the coffee beans and the dry beans—the ancient and honorable "Army beans"—were still there. Improvement was effected almost solely by "embroidering" the basic issue—supplementing it with garden produce and the game and wild berries and fruit of the Western plains. It is

(Continued on page 16)

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(Continued from page 14)

interesting to note that the basic issue, which was fixed by Congress, cost only 13 cents per ration—and a ration is by definition "enough food for one man for one day." This was about half the cost of feeding a soldier's civilian counterpart of those days.

World War I. World War I produced a remarkable and somewhat sudden improvement in military feeding. One reason was the greater sophistication in American food habits—and military feeding always follows national food habits. Another reason was the great advance of the food industry itself. Still another reason was the enlistment in food and ration improvement of American scientists (such as Dean Samuel Prescott of M. I. T.) and industrial specialists. For the first time in military history, supplying adequate, wholesome food to the Armed Forces became a broad-gauge, effective enterprise.

Curiously enough the basic issue of 1917 was not greatly changed over that of previous years. The flour and meat are still there—and the beans. But military feeding rapidly moved out from the confines of the basic issue to include a wide variety of canned foods, and, overseas at least, dehydrated foods, and (in modest quantities in terms of today) such items as frozen beef and soluble coffee.

Perhaps the scene to remember out of World War I is that shown in Figure 5. This scene is probably representative of food preparation in the A. E. F. segment of the combat zone of France. These A. E. F. cooks do not look too happy, but they are getting the job done in the face of combat stress and strain. We ought some day to be able to eliminate 90% of this type of effort—and fly in the food, precooked, ready-to-eat.

Figure 5

World War II. By the time of World War II interest in packaged ration systems was keen. Instrumental in rousing and then capitalizing on this highly needed interest in streamlining rations was Colonel Rohland A. Isker, commanding officer of the first Qm. subsistence research laboratory, established in Chicago in 1936, and therefore my earliest predecessor. Everyone is, or should be, aware of the magnificent job he did in adjusting rations to the circumstances of military use in a mechanized, world-sized war—incredibly advanced in weapons, tactics, and logistics over previous wars.

World War II packaged ration systems may be quickly listed as: rations to meet area needs (the mountain ration, for example); rations for combat use (the C ration); rations for emergency short-time use (the K ration). Effort was made to tailor rations to the circumstances of modern military operations. In Figure 6 you can glimpse the end result—a C ration being

Figure 6

eaten by Private Lloyd Culick who has been in the jungles of New Georgia and for 12 days has had no opportunity to take off his clothes. But he has had food—safe food, and even if he had to eat it with the lid he has just removed from the can, it probably tasted good. Not like a holiday dinner, but considering the circumstances, *good*.

Present Rations and the Future. What are we in the Armed Forces doing today and what will we be doing tomorrow to integrate in still greater degree the difficult business of feeding servicemen in the midst of military activities more exacting even than those of World War II?

In the first place, we have effected, and have had several years of experience in conducting, a system of coordination among the food research agencies of the Army, Navy, and Air Force. Under the assignment to the Army of primary responsibility for Armed Forces food research an excellent working relationship now exists among the Services; although each Service retains responsibility for solving food and feeding problems peculiar to its needs the solutions are often attained by a division of research and development labor, thus avoiding duplication of effort and saving both time and funds. In broad terms—and running the chance of oversimplifying things—the Qm. Institute at Chicago works on food problems of concern to all three Services; the Navy Research and Development Facility at Bayonne, New Jersey, concentrates on food preparation, food handling, and food equipment problems peculiar to the Navy ashore and afloat; the Air Force

(Continued on page 32 following technical papers)

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SELECTED ABSTRACTS . . .

Compiled by H. A. Campbell

ANALYTICAL METHODS

A new and simple technic for the direct determination of the equilibrium relative humidity of foods.

Mossel, D. A. A. *Food Research, 20,* 415-23 (1955).

A LiCl-cell, developed for the measurement of the dewpoint of air; has been adopted for the estn. of the equil. relative humidity of foods, resulting in a considerable time saving. Values for foods and NaCl solns. correlated satisfactorily with the data derived from measurements according to classical technics. Full description of app. is given.

Determination of some components in corn sirups by quantitative paper chromatography.

Whistler, R. L., and Hickson, J. L. *Anal. Chem., 27,* 1514-17 (1955).

Paper chromatography was demonstrated as a practical procedure for the quant. sepn. of nine corn sirup components. These components, in order of decreasing chromatographic mobility, have been tentatively identified as: glucose, maltose, isomaltose, maltotriose, isomaltotriose, maltotetraose, maltopentaose, maltohexaose, and maltopheptaose. The 9 components, sepd. chromatographically, were quantitatively detd. by adsorptiometric techniques. A no. of corn sirups differing in degree of hydrolysis were analyzed.

Separation and identification of cyclohexylsulfamate, dulcin, and saccharin by paper chromatography.

Mitchell, L. C. *J. Assoc. Offic. Agr. Chemists, 38,* 943-6 (1955).

The sweeteners are sepd. by paper chromatography in which acetone containing ten % (v/v) each of ethyl acetate and NH_4OH was used as the mobile solvent.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Influence of moisture content on enzyme reactions in moisture-deficient food stuffs, flour, dough and bread.

Kiermeier, F., and Coduro, E. *Z. Lebensm.-Untersuch. u-Forsch., 102,* 7-12 (1955).

Enzymatic degradation of starch on storage could be shown in flour, dry bread and wheat bread. Model expts. with flour-H_2O mixt. indicated proteolytic enzymes acting as amylase. Such activity could not be proven in bread and baked goods.

Action of chloramine-T and of ninhydrin on some synthetic oligopeptides.

Cristol, P., Benezech, C., and de Paulet, A. C. *Bull. soc. chim. France,* 1955, 183-9; *Chem. Abstr., 49,* 12553g (1955).

Chloramine-T and ninhydrin readily deaminate glycyl peptides but do not react readily with those peptides in which the first amino acid is not glycine.

A new method for the direct isolation of glycine from protein hydrolyzates.

Selim, A. S. M., El-Wahab, M. E. A., and El-Sadr, M. M. *Biochem. J., 61,* 177-9 (1955).

A new method for the isolation of glycine from protein hydrolyzates by its direct pptn. with copper picrate is described. The glycine-Cu picrate complex is readily decomposed by acids, and picric acid can easily be recovered. The introduction of undesirable reagents is avoided, and after the removal of glycine the hydrolyzate is left in a form suitable for the isolation of other amino acids.

A comparison of casein and nitrocasein as substrates for proteinases.

Ferguson, L. N., and Lovtrup, S. *Compt. rend. trav. lab. Carlsberg Ser. Chim., 29,* 193-207 (1955).

The relative merits of casein and nitrocasein as substrates for proteinase detn. were compared. Casein was found to be nearly completely solubilized by pure and crude trypsin while nitrocasein is rendered almost completely trichloroacetic acid-soluble by crude trypsin but only 50% trichloroacetic acid-soluble by pure trypsin.

BOTANY

Red tomatoes deficient in vitamin A.

McCollum, J. P. M. *Canning Trade, 78,* 14, November, 1955.

Good color and high vitamin A content in tomatoes cannot be had at the same time is indicated by work being done by J. P. McCollum at the Univ. of Illinois. McCollum says that color in tomatoes is the result of two pigments — lycopene, which augments red color and carotene a detracting element. Because of the opposite effect of carotene the researchers will decide which factor, color or vitamin A content, they will try to produce in new varieties of tomatoes.

MICROBIOLOGY

A device for growing bacterial populations under steady state conditions.

Fox, M. S., and Szilard, L. *J. Gen. Physiol., 39,* 261-6 (1955).

A device for maintaining an exponentially growing population of bacteria in the steady state of maximal growth rates is described.

A strain of Escherichia coli with an unusually high rate of auxotrophic mutation.

Goldstein, A., and Smoot, J. S. *J. Bacteriol., 70,* 588-95 (1955).

A strain (ATCC 11887) of *Escherichia coli* was described in which various auxotrophic mutants arise at phenomenally high rates, leading to mutant frequencies of several percent in ordinary wild-type populations. This strain may serve as a useful tool in studying the causes of "spontaneous" mutation.

A survey of the pigments of a number of chromogenic marine bacteria, with special reference to the carotenoids.

Courington, D. P., and Goodwin, T. W. *J. Bacteriol., 70,* 568-71 (1955).

A survey of a number of chromogenic marine bacteria indicates that the pigments present are generally carotenoids. Polyhydroxyxanthophylls predominate and carotenes are rarely observed. This picture is also characteristic of nonmarine bacteria. The pigment in *Serratia marinorubra* is prodigiosin. High pressure has no effect on the synthesis of carotenoids by marine bacteria.

NUTRITION

Starches, sugars, and related factors affecting liver fat and nitrogen balances in adult rats fed low levels of amino acids.

Womack, M., and Marshall, M. W. *J. Nutrition, 57,* 193-201 (1955).

Liver fat was reduced and negative N balances were decreased in adult protein-depleted rats fed extra threonine, corn, rice or wheat starch, or corn dextrin, when compared with the levels found for animals fed diets contg. sucrose and low levels of amino acids. Doubling the essential amino acid intake of animals receiving sucrose, glucose or fructose reduced liver fat to normal or near normal values.

Some observations on vitamin metabolism in germ-free rats.

Luckey, T. D., Pleasants, J. R., Wagner, M., Gordon, H. A., and Reyniers, J. A. *J. Nutrition, 57,* 169-82 (1955).

A vitamin balance study in germ-free rats showed that less niacin, riboflavin and biotin were excreted and accumulated in body tissues than were fed to the rat; quantities of pantothenic acid and vitamin B_{12} excreted are equal to the amts. fed; biosynthesis of inositol was not proven unequivocally; while vitamin B_c (measured as folic acid and citrovorum factor) was synthesized. Results from limited nos. of germ-free rats fed semisynthetic diets indicated that with an occasional exception the general metabolism of germ-free rats is very similar to that of conventional rats. A dietary source of biotin is required by germ-free rats. The

(Continued on page 20)

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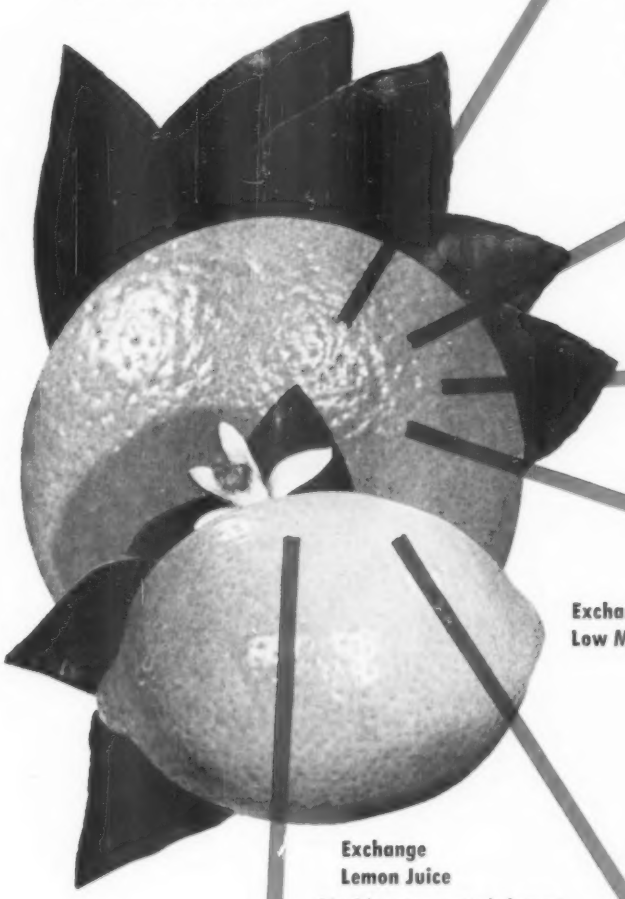

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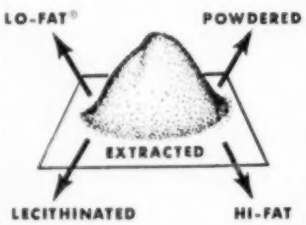

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(Continued from page 18)

main symptoms of biotin deficiency were retarded growth, eventual loss of wt., alopecia, dermatitis and skin ulcers.

The percentage of protein in corn and its nutritional properties.

HOGAN, A. G., GILLESPIE, G. T., KOCTURK, O., O'DELL, B. L., AND FLYNN, L. M. *J. Nutrition, 57,* 225 *37* (1955).

High protein corn diet contained 15% of protein and gave slight response to tryptophan. Responses were larger when either lysine or nicotinic acid were given. Low protein corn diet contained 7% protein and the rats which consumed it gave no response to single addns. of tryptophan or nicotinic acid or combinations of it.

The effect of fat level of the diet on general nutrition. XVI. A comparison of linoleate and linolenate in satisfying the essential fatty acid requirement for pregnancy and lactation.

DEUEL, H. J., MARTIN, C. R., AND ALFIN-SLATER, R. B. *J. Nutrition, 57,* 297-302 (1955).

Linolenate was found to be less effective than linoleate at all levels studied. However, when mixts. of linoleate and linolenate were given, the potency of linolenate was found to be equal if not greater than that of an equiv. total dose of linoleate.

Dental caries in the albino rat in relation to the chemical composition of the teeth and of the diet. I. Effect of prenatal and postnatal feeding of high protein, high fat and high carbohydrate diets.

HALDI, J., WYNN, W., LAW, M. L., AND BENTLEY, K. D. *J. Nutrition, 57,* 215-23 (1955).

The postnatal effect of a high-sucrose, high-protein or high-fat diet on the mineral compn. of the teeth of albino rats were studied by feeding these diets for a period of 150 days from weaning. The mothers of these animals had been fed only a stock diet. The prenatal effects were studied by feeding these diets to animals whose mothers had been raised on these diets and fed the same diets during pregnancy and lactation. The preponderance of any one of the major foodstuffs in the diet had neither a prenatal nor postnatal influence on the mineral compn. of the teeth. The greater cariogenicity of the high-sucrose is compared with the high-fat and high-protein diets and can not be ascribed to any changes induced in the mineral compn. of the teeth by a preponderance of sucrose in the diet.

The effects of sitosterol on serum lipids.

BEST, M. M., DUNHAM, C. H., VAN LOON, E. J., AND WATHEN, J. O. *Am. J. Med. Sci., 19,* 61 (1955); *Am. J. Clin. Nutr., 3,* 526 (1955).

The plant sterol, beta sitosterol in 20-25 gram doses, was given daily for a prolonged period to 14 patients. A sustained lowering of serum cholesterol, total lipids, neutral fat, and lipid phosphorus was observed. It was believed that the sitosterol competes for esterification in the process of cholesterol absorption.

Progress report on canine nutrition.

MCCAY, C. M. *Flour and Feed, 56* (1), 6 (1955); *Biol. Abstr., 29,* 25698 (1955).

A 3-year study indicates that methionine is useful in dog feed contg. low levels of meat scrap.

PHARMACOLOGY AND TOXICOLOGY

Study of possible complex formation between macromolecules and certain pharmaceuticals IX. Formation of iodine-iodide complexes with polyethylene glycol.

GUTTMAN, D. E., AND HIGUCHI, T. *J. Am. Pharm. Assoc., Sci. Ed., 44,* 668-78 (1955).

Investigation of the complexing reaction between polyethylene glycol and iodine in an iodine-potassium iodide aq. system has shown that at high triodide ion concns. and low free iodine concns. an insol. complex having a stoichiometric ratio of one mole of potassium triodide to approx. 10 monomeric units of the polymer is reversibly formed. The concn. dependencies of both complexing reactions on iodine, K ion and free iodine are presented in this report. The interaction in a Na iodide-iodine system also results in the formation of an insol. complex. Bromine in the presence of bromide ion has also been shown to form a reversible insol. complex with polyethylene glycol.

Studies in vanadium toxicology.

MOUNTAIN, J. T., STOCKELL, F. R., AND STOKINGER, H. E. *Arch. Ind. Health, 12,* 494-502 (1955).

A highly sensitive test of vanadium action in man was demonstrated. This test depends on the quant. measurement of the sulfur-contg. amino acid cystine in the fingernails of vanadium-exposed persons. Values of cystine depressed 1% below that of normal are considered abnormal and indicative of altered amino acid metabolism brought about by vanadium in the absence of other conditions known to effect a similar change. Industrial workers with sufficient, but very minimal exposures, respond alike with lowered fingernail cystine values irrespective of the character of the vanadium material to which they have been exposed.

PHYSIOLOGY AND MEDICINE

On the question of formation of benzoic acid in animal body.

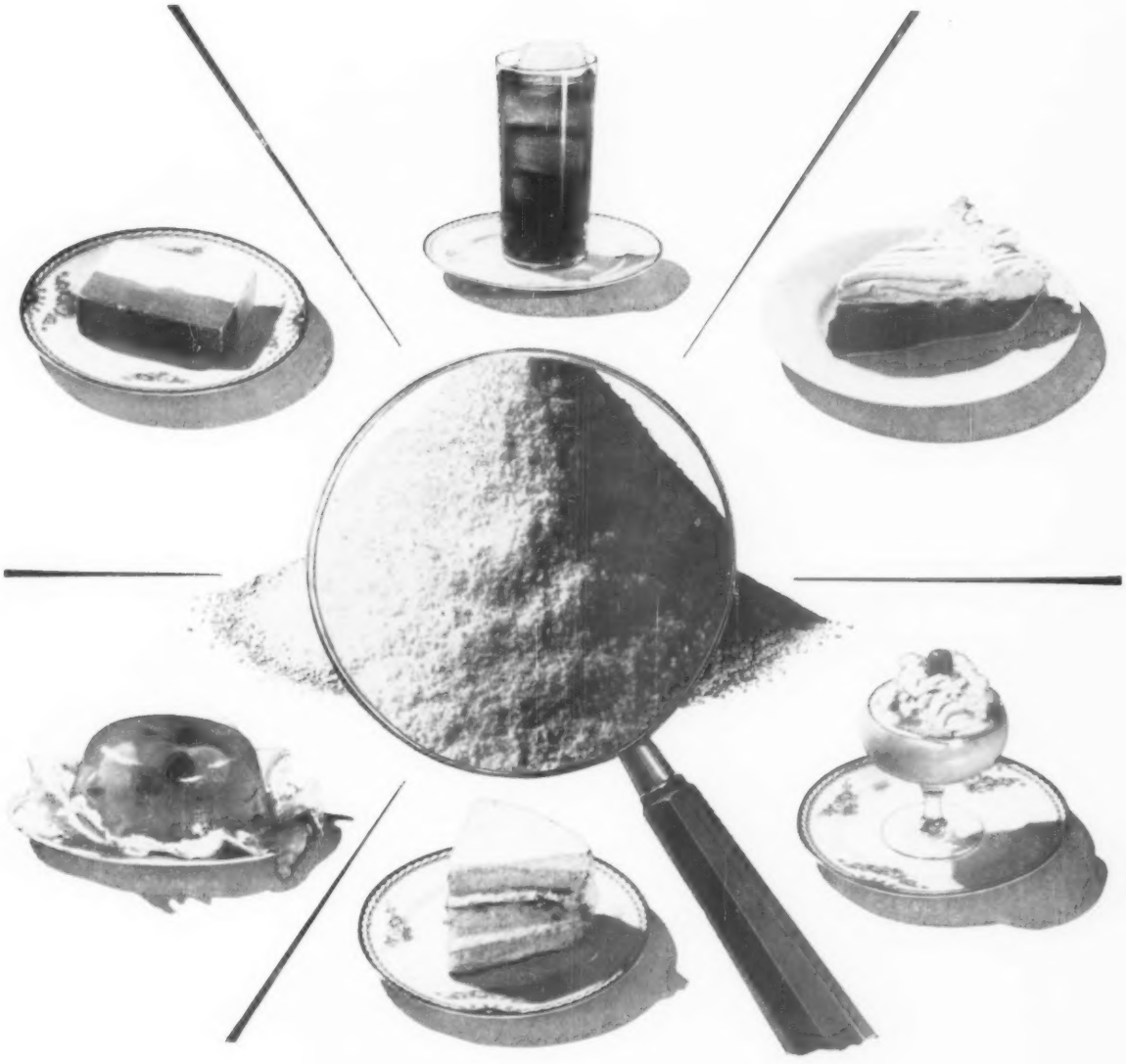
BERNHARD, K., VUILLEUMIER, J. P., AND BRUBACHER, G. *Helv. Chim. Acta., 38,* 1438-44 (1955).

Rats administered benzoic acid labelled with C^{14} display practically no radioactivity in the expired CO_2. After a short time 90% of the applied activity can be demonstrated in hippuric or benzoic acid of the urine.

Stress and the vascular system.

RIEGEL, C. *Geriatrics, 10,* 523-32 (1955).

(Continued on page 22)



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(Continued from page 20)

A review of the chemistry of vascular deterioration, stressing the changes in lipid constituents of blood and their possible relation to development of an atherosclerosis.

Ketocholanic acids as an adjunct in management of high fat diet allergies.

LEPORE, J. J. *Am. J. Digest. Diseases, 22,* 318-9 (1955).

Three cases of allergy to fatty foods are reported. Favorable clinical results were obtained by low fat diet and Triketol therapy. The clearing of the allergic condition was permanent in spite of return to ingestion of fatty foods without medication. These experiences suggest that the faulty fat metabolism was of a temporary nature.

Relation of dietary fat to the absorption and elimination of exogenous and endogenous cholesterol.

TSUNG-MIN, L., KARVINEN, E., AND IVY, A. C. *Am. J. Physiol., 183,* 86-90 (1955).

Tallow, corn oil, triolein, oleic acid, trielaidin, tripalmitin, and palmitic acid were studied. It was found that oleic acid definitely and tallow slightly decreased the endogenous elimination of cholesterol (CS), whereas corn oil and triolein definitely increased it. Oleic acid augmented the absorption of exogenous (dietary) CS to a greater extent than a low-melting tallow, corn oil and triolein. Tripalmitin, trielaidin and palmitic acid actually decreased the absorption of CS. With the exception of triolein, the % of dietary CS absorbed varied directly with the % of utilization of the fat fed with the CS. The extent of utilization and the m.p. of the fats used, and the solubility of CS in them did not adequately explain these differences. It was suggested that results of a study of the ease of esterification and relative absorbability of the esters of CS may provide the explanation.

Absorption of dihydrocholesterol and soya sterols by the rat's intestine.

IVY, A. C., TSUNG-MIN, L., AND KARVINEN, E. *Am. J. Physiol., 183,* 79-85 (1955).

The results indicate that dihydrocholesterol and soya sterols decrease the absorption of cholesterol by competing for the total capacity of the sterol absorptive mechanism on the basis of their relative absorbabilities.

ENGINEERING AND PLANT EQUIPMENT

Dryers and drying costs.

RUSSELL, R. J. *Chem. Eng. Costs, Quart., 5,* 96-104 (1955).

Summary article describing various types of dryers available, flow sheets showing processes, and charts showing how to estimate drying costs.

Drying design and costs.

LAPPLE, W. C., CLARK, W. E., AND DYRDAL, E. C. *Chem. Eng., 62,* 177-200, November (1955).

The application of modern drying theory towards the design of com. dryers is discussed. Equipment cost data is correlated showing the actual data that the correlation is based on. Estimates of dryer operating costs are also given.

Relative performance of sieve and bubble-cap plates.

JONES, J. B., AND PYLE, C. *Chem. Eng. Progress, 51,* 424-28 (1955).

The authors compare the sieve plate and the bubble-cap plates with regard to pressure drop, plate efficiency, entrainment characteristics and cost. The sieve plate is found to be superior.

Correlation of experimental data on the disintegration of liquid jets.

MIESSE, C. C. *Ind. Eng. Chem., 47,* 1690-1701 (1955).

Theories of jet disintegration are summarized and evaluated and data of other investigators is compared with data obtained experimentally. An extensive program of research is recommended to confirm validity of these correlations and to investigate variables not considered so far.

Ultrasonic gas analyzer.

KNIAZUK, M., AND PREDIGER, F. R. *Instruments, 28,* 1916-17 (1955).

An app. is described that is capable of detecting a change of 0.01% in the oxygen concn. of a gas. This is particularly useful in basal metabolism studies.

How to find best site for new plant.

BIERWERT, D. V., AND KRONE, F. A. *Chem. Eng., 62,* 191-7, December (1955).

A review of detg. the economic aspects of plant location, put forth in a series of logical steps to aid management in making a final decision.

FOOD AND FOOD TECHNOLOGY

BAKING AND BAKERY PRODUCTS

A comparison of the effects of bromate and calcium stearyl-2 lactylate on bread quality.

THOMPSON, J. B., AND BUDDEMEYER, B. D. *Cereal Chem., 32,* 493-8 (1955).

Ca stearyl-2 lactylate caused an improvement in bread quality similar in extent and kind to that brought about by $KBrO_3$. The effects of the two improvers were additive but were probably due to different modifications of the dough.

The diffusion of carbon dioxide through fermenting bread sponges.

BURTLE, J. G., AND SULLIVAN, B. *Cereal Chem., 32,* 488-92 (1955).

Radioactive CO_2 was used to test the permeability of fermenting sponges to CO_2. Results showed that the CO_2 retained above a fermenting dough in cabinet fermentation is easily capable of diffusing back into the sponge even against the developing internal gas pressure of the mass. The data support the free diffusion theory suggested by Sullivan and Richards.

Gluten oxidizing capacity of soya.

LOGAN, J. L., AND LEARMONTH, E. M. *Chemistry & Industry, 39,* 1220-21 (1955).

Experiments show that raw soya flour produces oxidation of gluten and consequent strengthening of dough contrary to previous reports which stated that addn. of soya reduces dough strength.

Temperature triggered.

Monsanto Mag., 35, Oct.-Nov., 16-17 (1955).

A new controlled leavening agent, dicalcium phosphate has been introduced by Monsanto. The product retains its alkalinity in normal room temps., does not absorb moisture from the air and only temps. of 170° or more turn it into an acid. In dry mix it has a long shelf life and will remain stable under varying storage and shipping conditions.

COCOA PRODUCTS

Improving cacao butter by hydrogenation or isomerization.

NEWMAN, A. A. *Food Manuf., 30,* 286-9 (1955).

Cacao butter characteristics can be improved either by hydrogenation or isomerization. Fat bloom in finished chocolates can be controlled by these treatments, the hydrogenation process being more effective.

FATS AND OILS

Carbonyl compounds in rancid corn oil.

BUSS, C. D., AND MACKINNEY, G. *J. Am. Oil Chemists' Soc., 32,* 487-9 (1955).

Fourteen petr. ether-sol. and 16 insol. dinitrophenylhydrazine derivs. were isolated from rancid corn oil and their properties discussed. Evidence suggests that γ-undecanal and γ-undecenal are among the components of the rancid oil.

FLAVORS AND FLAVORING

Imitation cherry flavor.

JACOBS, M. B. *Am. Perfumer Essent. Oil Rev., 66,* 52-4, September (1955).

A review is given of the investigations on the compn. of natural cherry flavors. Suggested formulations are given.

FRUIT AND FRUIT JUICES

Glutamic acid decarboxylase of lemons and oranges.

AXELROD, B., JANG, R., AND LAWRENCE, J. M. *J. Agr. Food Chem., 3,* 1039-41 (1955).

The flavedo of lemon and orange fruit is among the richest plant sources of glutamic acid decarboxylase hitherto reported. Even a most rudimentary fractionation of the enzyme from orange

(Continued on page 24)

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flavedo yields a prepn. with an activity of about 40,000 cu. mm. of CO_2 per hr. per mg. of protein N.

MEAT AND FISH

Effect of irradiation on meat fats.

SRIBNEY, M., LEWIS, U. J., AND SCHWEIGERT, B. S. *J. Agr. Food Chem., 3,* 958-60 (1955).

Studies on chem. changes in meats during irradiation were directed to meat fats. Off-odors produced during irradiation of certain meats at sterilization levels do not arise directly from chem. changes in the meat fats. Oxidative changes (peroxide, carbonyl, and free fatty acid formation) are not marked during irradiation or subsequent storage, if the presence of oxygen is minimized.

POTATOES

Phenolic compounds in potato tissue.

CHEING, R. C., AND HANNING, F. *Food Research, 20,* 506-11 (1955).

Tannins were found to be more concd. in the skins that in the center flesh. There was a slightly greater content of tannins in the stem end than the bud end. No correlation could be established between color scores and tannin content of various varieties and samples. By paper chromatographic technic, chlorogenic acid was found to be the only tannin-like substance present in detectable amts. in exts. obtained from the skins, the discolored areas and the center flesh. In addn., in the skin extract, caffeic acid was present. L-Tyrosine was found to be present in detectable amts. in the discolored areas and the center flesh of the tubers.

Crystalline inhibitors of trypsin from potato.

SOHONIE, K., AND AMBE, K. S. *Nature, 176,* 972 (1955).

A method of prepg. the potato inhibitor fractions as well as the different physicochem. properties are reported.

The effect of nitrogen fertilization upon potato yields and chipping quality.

EASTWOOD, T., AND WATTS, J. *Am. Potato J., 32,* 388-9 (1955).

The various N levels used had no influence, directly or indirectly, upon the percent of reducing sugar in the tubers, the keeping quality of the tubers in curing or conditioning storage, the keeping quality of the potatoes in previous cool/cold storage, and upon the taste of the potato chips.

PRESERVATION AND STERILIZATION

Chlortetracycline in the prevention of bacterial spoilage of certain foods.

DENTON, J. J. *Assoc. Food & Drug Officials, U. S., 19,* 151-4 (1955).

Chlortetracycline was found to be the most effective antibiotic against food spoilage bacteria in 3 major commodities; fish, beef and poultry.

SEASONINGS

Antioxidant properties of spices in oil-in-water emulsions.

CHIPAULT, J. R., MIZUNG, G. R., AND LUNDBERG, W. O. *Food Research, 20,* 443-48 (1955).

All of 32 spices studied protected the emulsion against O_2 absorption. Cloves were extremely effective. Other spices with antioxidant indexes greater than 5.0 were: allspice, cardamon, cassia, cinnamon, ginger, mace, nutmeg, oregano, black pepper, white pepper, rosemary, sage, savory, thyme, and turmeric.

SUGARS, STARCHES AND SIRUPS

The constitution of a modified starch from malted barley.

ASPINALL, G. O., HIRST, E. L., AND MCARTHUR, W. *J. Chem. Soc.,* 3075-81 (1955).

The starch from malted barley has been isolated and shown to contain 26.0% of amylose. Methylation showed that the amylose consisted of unbranched chains containing an av. of *ca.* 330 glucose residues. Methylation end-group assay, supported by β-amylolysis and periodate oxidation, indicated that the amylopectin contained the normal type of branched structure, but with one non-reducing terminal group per 18 ± 1 glucose residues. It is concluded that during the malting of barley the amylopectin has undergone enzymic attack causing shortening of the outer chains but with retention of the branched structure, while the amylose component has been relatively little degraded.

TASTE AND TASTE TESTING

Development of a scale for measuring soldiers food preferences.

PERYAM, D. R., AND THURSTONE, L. L. *Food Research, 20,* 512-20 (1955).

Attempts were made to improve the deficiencies of the "hedonic scale." Although the objective was not reached, the following important points were proved. No consistent relationship is found between reliability and no. of intervals on the scale. Larger scales, up to 9 intervals, tend to be more sensitive to differences among foods. Elimination of the "neutral" category seems to be beneficial. Balance is not an essential feature of a rating scale.

ORGANIC CHEMISTRY

The rate of inversion of sucrose in the presence of sulphate.

GUGGENHEIM, E. A., HOPE, D. L., AND PRUE, J. E. *Trans. Faraday Soc., 51,* 1387-91 (1955).

The rate of inversion of sucrose was measured in aq. mixts. of bisulphate and sulphate at 25° C. The measured rates agree within about 1% with values calcd. from previously detd. values of the acidity constant of HSO_4^- and of the primary kinetic salt effect, without the introduction of any new adjustable parameters.

PHYSICAL RESEARCH

A comparison of the properties of various preparations of sodium alginate.

VINCENT, D. L., GORING, D. A. I., AND YOUNG, E. G. *J. Appl. Chem., 5,* 374-8 (1955).

Fifteen specimens of Na alginate were prepd. from various brown algae and the degree of purity and phys. properties such as viscosity, optical activity, ionic mobility and sedimentation rate were measured.

MISCELLANEOUS INFORMATION

Food wastes made into profitable product.

BONDI, H. S. *Food Eng., 27,* 84 (1955).

A process is described by which discarded citrus pulp, corn cobs, fruit and vegetable refuse, coffee grounds, etc. are converted by bacterial cultures to an organic fertilizer. The process requires 16-24 days.

Humidity and corrosion.

AMBLER, H. R. *Nature, 176,* 1082 (1955).

Table is presented showing that corrosion at 2 sites of roughly equal humidity may range from "highest anywhere" to less than in rural places, the operative variant being salinity.

PATENTS

Process of preparing an aluminum caseinate.

PATERSON, L. O. 2,721,861, October 25, 1955.

A process of prepg. an acid-sol. Al proteinate useful as an antacid.

Stabilization of organic compounds.

ROSENWALD, R. H. Assignor to Universal Oil Products Company. 2,721,804, October 25, 1955.

A method of stabilizing a fatty material against rancidity which comprises incorporating therein a stabilizing amt. of an antioxidant compn. comprising from about 1 to about 20 parts by wt. of 2,4,6-tri-alkylphenol and from about 1 to about 20 parts by wt. of NDGA.

Method of producing frozen citrus concentrate of improved stability.

BRENT, J. A., BROWN, W. W., AND ROY, W. R. Assignors to Minute Maid Corporation. 2,724,652, November 22, 1955.

A process of concg. orange juice which comprises sepg. the juice into a pulp fraction and a liquid fraction contg. less than 3% pulp, pasteurizing the pulp fraction by maintaining it at a temp. between 135 and 185° F. for not more than 3 minutes, cooling the pasteurized pulp fraction, concg. the liquid fraction to approx. 60° Brix at a temp. below sterilization temp., mixing the cooled pasteurized pulp fraction with the concd. liquid fraction.

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Development of a Frozen Pea Reference Standard for Taste Tests Involving Storage

Alice Collings Ward and Mildred M. Boggs

Western Utilization Research Branch, Agricultural Research Service, United States Department of Agriculture, Albany 10, California

(Manuscript received December 12, 1955)

The purpose of the investigation was to find means for preserving frozen pea sample so that it would not develop any off-flavor during one year of storage. Such a sample was needed as a reference and control sample for taste tests involving storage. When peas were handled and processed under excellent conditions, judges could not distinguish between the following pairs of samples: (a) packs stored in air and in nitrogen for 13 months at −60° F.; (b) packs stored in air at −30° F. and at −60° F. for 13 months; and (c) packs in air or nitrogen stored 13 months at −60° F. and freshly prepared packs of comparable raw material. Air packs, hermetically sealed, of frozen peas stored at −30° F. or below are recommended for controls in taste-panel work when storage time does not exceed 13 months.

A taste test for the purpose of determining flavor stability of a food during storage is most useful when it includes a control sample that does not change during the test period. Control samples stored at −10° F. and −30° F. had been used routinely in this Laboratory in storage studies with frozen peas, and they were known to retain their flavor reasonably well. However, conclusive evidence of reliability was not available.

The present investigation was undertaken to produce a frozen pea sample that did not develop off-flavor during one year and to establish its reliability as firmly as it is possible to do with a perishable food. Such a control sample would be used then in routine taste tests either as a hidden control or as a labeled reference, or more often for both purposes.

Two approaches to the problem seemed possible. One was to store peas at lower and lower temperatures until a level was reached where judges could not distinguish between the last two. Another approach was to compare peas of one harvest year, stored under the most promising conditions, with fresh peas of the next harvest year. There was a possibility with the latter approach, of course, that the raw material of the 2 years might differ because of climatic or other growing conditions. Both techniques were used.

The raw peas were carefully selected and then handled and processed under the best conditions known. Preparation variables included machine- and hand-shelling and nitrogen and air packing. Storage temperatures investigated were −60° F.,[a] −30° F., and −10° F. Freshly frozen samples were compared with fresh peas of the same lot in order to determine whether flavor was affected by processing alone, without storage. At the termination of the experiment nitrogen and air packs stored 13 months at −60° F. were compared with freshly processed peas of similar history from the next harvest year.

RAW MATERIAL AND PROCESSING PROCEDURES

The peas for the main investigation were Morse's No. 9, an improved Laxton's Progress variety. They were grown in 1949 under conditions for fresh market peas on non-irrigated land near Half Moon Bay in the California coastal area. This variety is used for freezing preservation as well as for the fresh market.

[a] The storage was an insulated cabinet refrigerated with dry ice. The actual temperature fluctuated substantially but rarely rose above −60° F.

Four lots of pod peas harvested at weekly intervals were used as replicates. Selection during hand-picking provided 4 lots of approximately the same maturity (tenderometer readings on peas of sizes 3 to 5 inclusive varied from 79 to 83 for these lots). Each lug of peas was heavily iced in the field as soon as it was filled. The peas to be tested in the fresh state were transferred to a room at 33° F. as soon as they reached the Laboratory. The bulk of each lot was processed immediately and was on trays in the freezer 5 hours after harvest or 30 minutes after machine shelling. Slightly longer delay occurred for the hand-shelled peas.

Standard processing procedure was as follows: The pods were mechanically shelled and then size-graded, sizes 3 to 5 inclusive being retained. Quality grading by brine separation was not necessary because of selection during hand-picking. The peas were blanched in flowing steam for 60 seconds, fog cooled for 2 minutes, and tray frozen under a fan in a room at −10° F. Peroxidase and catalase tests on the blanched peas were negative. As soon as the peas reached approximately −10° F. they were packed in air in No. 2 tin cans, hermetically sealed, and transferred to storage at −60° F. Variations from this standard process for the different tests are reported below.

The following groups of samples were evaluated by judges: (a) frozen standard-process peas and fresh hand-shelled peas, 20 hours after harvest; (b) blanched machine- and hand-shelled peas prepared by the standard process and unblanched, hand-shelled frozen peas, all stored 3 months at −60° F.; (c) standard-process peas stored at −60° F., −30° F., and −10° F. for 4, 8, 10, and 13 months; and (d) 1949 air and nitrogen packs stored 13 months at −60° F. and 1950 air packs stored 1 month at −60° F.

COOKING AND APPRAISAL PROCEDURES

Three hundred grams of frozen or fresh peas were added to 150 ml. of boiling distilled water and cooked for 5 minutes after resumption of boiling (unblanched frozen peas were boiled 6 minutes in order to obtain equal "doneness"). Drained cooked peas with 100 ml. of cook-liquor were disintegrated in a kitchen-type blender in order to mask texture differences, and 2 to 3 drops of red vegetable coloring were added to mask any color differences that might exist.

Samples were ranked by 10 to 12 trained, selected judges in order of increasing amounts of off-flavor, rank 1 indicating least off-flavor. A labeled reference of standard-process peas was submitted at each taste session. Peas of one harvest lot were tasted together and the order of samples was randomized.

Individual ranks for each test were treated statistically by analysis of variance and the q values were calculated.[b] Sources of variation considered were treatment, treatment by judge

[b] Observed $q = \dfrac{\text{Largest Mean} - \text{Smallest Mean}}{\sqrt{\dfrac{\text{Mean Square of Error}}{\text{No. of Judgments Per Treatment}}}}$

Significance tables for q values have been given by Pearson and Hartley (6).

interaction, treatment by replicate interaction, and remainder. If both interactions were non-significant, their variances were pooled with error variance. When the q value was significant, the Tukey* least significant difference value (5% level) for all pairs of treatment means was calculated.

PRELIMINARY INVESTIGATIONS

Methods. Extensive preliminary work was done with two harvest lots of Giant Stride peas in 1948. Handling and processing procedures were the same as those used in 1949 except that peas of sizes 3 to 6 inclusive were used.

Drained whole peas were evaluated by the modification of the triangle test described by Lindquist *et al. (5)*. Six replications (all possible orders of the 3 samples) of each harvest lot and each temperature comparison were included, giving 72 to 88 judgments per test.

Results. Comparison of lot 1 peas stored at —60° F. and —10° F. showed that differences were not significant when peas were stored 3.5 or 5 months, but they were significant after 7 months of storage. In the latter case peas stored at —10° F. had the larger amount of off-flavor. For harvest lot 2, differences were significant for all periods tested, namely 4.5, 5.5, and 7 months.

The more rapid development of off-flavor in lot 2 peas probably was due to the fact that they were less mature than lot 1. The tenderometer reading of lot 2 peas was 85 and lot 1, 94. Unpublished work in this Laboratory has shown that less mature peas in this tenderometer range developed off-flavor with shorter storage periods at a given temperature than did more mature peas.

Hardy *(3)* and Hunter *(4)* color measurements of conversion of chlorophyll and pheophytin *(2)* showed the same trends of change in the two lots of peas as the judges found.

The findings mentioned above and the unpublished work relative to the influence of maturity were the basis for use of quite immature peas in the main investigation. It was considered desirable to conduct the investigation with peas which were especially susceptible to flavor deterioration.

There were no significant differences between peas stored at —60° F. and at —30° F. for either harvest lot for any storage time tested. The longest periods tested were 9 months for lot 1 peas and 10 months for lot 2 peas.

MAIN INVESTIGATION

Results and discussion. The average off-flavor rankings and significance data for all tests of 1949 are summarized in Table 1. Section A of the table shows that the freezing process alone did not influence flavor of the peas. The pods for the fresh peas had been heavily iced during the first 5 hours after harvest, and they were held in a room at 33° F. during the next 15 hours while waiting for the processed material to become available. Boggs and Talburt *(1)* showed that flavor change did not occur in similar peas under these holding conditions.

* L. S. D. = $\sqrt{\frac{\text{Mean Square of Error}}{\text{No. of Judgments Per Treatment}}} \times \text{Table } q$

TABLE 1

Average off-flavor rankings for peas handled under several conditions[1]

A. Influence of Freezing Process without Storage

Time of test	Frozen peas	Fresh peas	Significance[2]
50 hrs. after harvest	1.49	1.51	not significant

B. Comparison of Blanched, Machine and Hand-Shelled Frozen Peas with Unblanched Hand-Shelled Frozen Peas

Storage	Blanched peas		Unblanched hand-shelled	L.S.D. at P = 0.05
	Machine-shelled	Hand-shelled		
3 months at —60° F.	1.44	1.68	2.88	0.18

C. Influence of Storage at —60° F., —30° F., and —10° F.

Storage period months	Storage temperature			L.S.D. at P = 0.05
	—60° F.	—30° F.	—10° F.	
4	1.83	1.95	2.22	0.34
8	1.74	1.66	2.60	0.22
10	1.62	1.56	2.81	0.26
13	1.68	1.68	2.64	0.27

D. Comparison of 1949 Air and Nitrogen Packs Stored 13 Months at —60° F. with 1950 Air Packs Stored 1 Month at —60° F.

1949 Nitrogen pack	1949 air pack	1950 air pack	Significance[2]
2.14	1.82	2.04	not significant

[1] Rank 1 indicated least off-flavor.

[2] When analysis of variance showed that there were no significant pairs among treatments the L. S. D. was not calculated.

Section B of Table 1 shows that hand-shelled peas had significantly more off-flavor than did machine-shelled peas, when both lots were blanched and both were stored 3 months at —60° F. This unexpected result may have been due to warming during the slightly longer time required to hand-shell the peas. Unblanched, hand-shelled peas received a markedly poorer rating than did blanched peas after 3 months of storage at —60° F. This was true for both the hand-shelled and machine-shelled blanched peas. This finding was not entirely unexpected. However, it had been hoped that the unblanched material might stand up for short periods at this very low temperature. Such a sample would have been very useful in certain investigations had it retained its flavor.

Section C of Table 1 shows that peas stored at —60° F. did not differ significantly in flavor from those stored at —30° at any period tested, namely, 4, 8, 10, and 13 months. At the end of 4 months' storage period there was a trend showing that peas stored at —10° F. had slightly more off-flavor than those stored at —30° F. but the difference was just under the borderline for significance of probability of 0.05. The difference between peas stored at —10° F. and —60° F. was barely significant after 4 months. With all longer storage periods, namely, 8, 10, and 13 months, the peas stored at —10° F. clearly had sufficiently more off-flavor than those stored at —30° or —60° F. to justify storage of reference samples at the lower temperatures.

Section D of Table 1 shows that neither the air nor the nitrogen packs of 1949, which had been stored 13 months at —60° F. differed significantly from the 1950 pack which had been stored 1 month at the same temperature, and the air and nitrogen packs did not differ significantly from each other. These data provide con-

vincing evidence that well handled peas stored either in air or nitrogen at —30° F. or —60° F. are suitable material for reference and control samples for taste test work. Usually, air pack would be selected for control work rather than nitrogen pack because it is more convenient. Since —30° F. storage yielded as good flavor as —60° F. it would be preferred in most instances because of its availability.

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New Developments in the Dehydration of Fruits and Vegetables

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Research and development work on dehydration of vegetables, fruits and fruit juices has made many extraordinary advances during and subsequent to World War II. At the beginning of the war, the technologist knew how to produce many dehydrated vegetables, fruits and fruit juices which, when freshly prepared, were of excellent quality, but he did not know how they must be prepared and stored so that they would retain their high quality for longer than a few weeks. Since then, not only have improved dehydration procedures been perfected, but the importance of reducing the moisture content in the dehydrated products to a very low level, in order to obtain stable products, has also been demonstrated. Further, a system of "in-package desiccation" has been worked out which makes possible the great reduction of moisture without simultaneously causing product deterioration.

Many of the improvements in dehydration techniques have not yet been adopted by commercial dehydrators. Moreover, few of the improved dehydrated products are available on the market. Since many of these products are equal or superior to the best canned and frozen foods, it is probable that an important civilian market will be developed in the not too distant future, for some of these dehydrated fruits, fruit juices and vegetables.

IMPROVEMENTS IN DEHYDRATING FRUITS

The interaction of reducing sugars and amino acids or proteins (the Maillard reaction), causes objectionable browning of most dehydrated fruits which have been prepared according to the usual commercial procedures. If the fruit is sulfured—as is common practice in the case of peaches and apricots, apples and some raisins—enzymatic browning is inhibited, and nonenzymatic browning is retarded. Barger, Pentzer, and Fisher *(2)* have shown that browning may be greatly retarded by refrigerating the dried or dehydrated fruit. More recently, it has been found that the rate of this reaction may be very greatly reduced by reducing the moisture content to 1% or less. However, it is next to impossible to lower the moisture content of a whole fruit, such as a prune, or even a half fruit, such as a dehydrated peach or apricot, to this low level without subjecting the product to such prolonged heating that the fruit is damaged. But, if the fruit is comminuted, it is possible to pull out the moisture by dehydration in a high vacuum, without subjecting it to high temperatures. To obtain greater stability, apples, apricots, peaches and other fruits are sometimes partially dehydrated in currents of warm air. Later, these partly dehydrated fruits are comminuted and then reduced to a low moisture content in vacuum dehydrators. The resultant product is much more stable than the partially dehydrated fruit.

DEHYDRATING FRUIT JUICES

A considerable quantity of dehydrated lemon juice is produced commercially by spray drying a mixture of low conversion corn syrup and single strength lemon juice usually in the proportion of 20 parts corn syrup solids to 100 parts lemon juice solids. Great difficulty is encountered in spray drying lemon juice without the addition of the corn syrup solids. However, the addition of the corn syrup modifies the taste and viscosity of the reconstituted lemon juice and as a result the spray dried product cannot be used for certain purposes where the unsweetened juice of full flavor is required.

Strashun and Talburt *(19, 20)* and others of the Western Utilization Research Branch of the U. S. Department of Agriculture, have perfected a method of dehydating orange juice which yields a powder which can be easily reconstituted to obtain beverage juice of good quality. Further, the product, unlike dehydrated juices produced by other processes, retains its high quality throughout a long storage period at 70° F. or for 6 months or longer at 100° F., Mylne and Seaman *(13)*. The method, sometimes called "puff-drying," in-

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volves (A) a preliminary concentration of freshly pressed orange juice at a low temperature under a high vacuum by a process similar to that commonly used for the production of frozen orange concentrate. The vacuum concentration is carried far enough to obtain a product containing about 65% soluble solids and not less than 7% nor more than 15% pulp. From here on the process differs from that used in preparing frozen concentrate, since the product is not cut back with fresh juice, nor is the product frozen. (B) Before continuing the dehydration, sufficient sodium bisulfite is added to obtain a 250 p.p.m.sulfur dioxide content on a total solids basis. (C) The sulfited orange juice concentrate is run on to a tray on a shelf in a vacuum dehydrator. A very high vacuum is pulled on the dehydrator. Moderate heat applied to the shelf causes the orange concentrate to puff up to several times its original volume. When the moisture content of the orange juice has been reduced to about 3%, the dehydration is discontinued, and the cake removed to an air-conditioned room of low humidity, where the cake is crushed and ground. Flakes of sorbitol containing an emulsion of cold pressed orange oil are added in order to return to the powder the oil lost during concentration and dehydration. The powder is then put into tin cans, a small paper bag of in-package desiccant (granular calcium oxide) is added and the can closed under either a high vacuum or nitrogen. The calcium oxide slowly absorbs nearly all of the moisture left in the orange juice powder, leaving less than 1%.

More recently, the Chain Belt Company *(1, 6)* has perfected a continuous vacuum dehydrator which has proved to be highly satisfactory for the continuous production of orange juice powder by a process similar to that described above. The Chain Belt apparatus consists of a vacuum chamber housing an endless stainless steel belt running over two drums, one hot and the other cold (Figure 1). From a feed tank outside the concentrator, orange juice concentrate is pumped into a trough within the vacuum chamber in which a pressure of 1 to 1.5 mm. mercury is maintained. A feed roller, suspended within the trough, transfers the concentrate to the bottom of the belt between the hot and cold drums. The belt transfers a thin layer of concentrate up and over the hot drum which is maintained at 100° F. Electric heaters, placed around the belt starting at the feed roller and stopping at the cold drum, supply extra heat in order to hasten dehydration. Dehydration begins immediately after the concentrate is applied to the belt and continues up to the cold drum. The dehydrated film of orange juice on the belt is cooled and made brittle by passage over the cold drum, which is maintained at about 0° F. and then scraped off the belt by an oscillating doctor blade. The product, which as a rule contains less than 3% moisture, drops into a trough and is conveyed by a screw conveyor to a chute leading to a product receiver located in an air-conditioned room. As in the case of the product produced in a vacuum shelf dehydrator, sorbitol crystals containing orange oil are added and the product packed in an inert atmosphere with an in-package desiccant. This process is now being successfully used in Florida for the production of orange and grapefruit powders ("crystals").

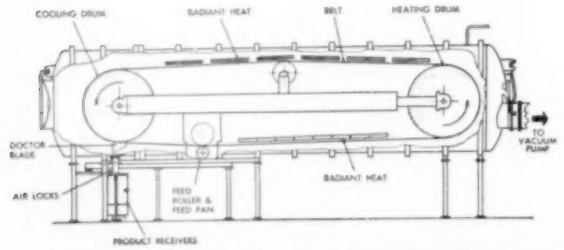

Figure 1. Functional diagram of the Chain Belt vacuum dehydrator.

VEGETABLE DEHYDRATION

One of the great advances made by the food technologist during the past decade has been the perfection of processes of dehydrating and storing various vegetables which retain their good quality for six or more months at 90°-100° F. The list of these high quality vegetables is not long but it is growing. It includes diced potatoes, potato granules *(4, 14, 16)*, onions, peppers, green beans, lima beans, sweet corn and one or two others. Some of the more important advances that have made this possible are the following:

(a) Recognition of the fact that almost all vegetables must be blanched (heated in boiling water or steam) to inactivate enzymes.

(b) Discovery that certain vegetables are much more stable if sulfured (treated with a sulfite), e.g., sweet corn and potatoes.

(c) Recognition of the fact that practically all vegetables must be reduced to a low moisture content, e.g., 4% or under in order to obtain desired stability.

(d) Discovery that some vegetables can be dehydrated more readily, and reduced to a much lower moisture content if they are first blanched and then frozen before dehydration, e.g., green beans.

(e) Recognition of the fact that the use of an "in-package" desiccant in a container of dehydrated vegetables makes it possible to reduce the residual moisture content to such a low level that the product is not subject to non-enzymatic browning (i.e., the Maillard reaction) *(9, 10, 11)*.

The process of dehydrating green beans described below, which has produced one of the outstanding dehydrated vegetables, is based upon these principles. Blue Lake or Tendergreen beans are steam blanched, cooled, sulfited, frozen, thawed, and dehydrated in a moving air current in a tunnel dehydrator first at 195° F. and then at 145° F. to a moisture content of approximately 5%. The product retains color and flavor amazingly well even when stored at 100° F. for 6 months, comparing favorably with good frozen beans.

Great improvements have also been made in the dehydration of sweet corn. The improved process may be described briefly as follows:

Sweet corn is cut from the cob, steam blanched, cooled, sulfited sufficiently to produce a dehydrated corn

containing 1500 to 2000 p.p.m. sulfur dioxide, and then dehydrated with moving hot air to a moisture content of approximately 5% *(15)*.

Recently, it has been found possible to produce greatly improved dehydrated green peas by cutting or slitting the skins so as to permit more rapid dehydration *(7)*.

SPECIAL PROBLEMS ENCOUNTERED IN DEHYDRATING TOMATO JUICE

When tomato purée of good quality is spray dried in currents of warm air, the resultant product is bright red in color but is difficult to reconstitute *(12)*.

If the tomato purée is dehydrated on a Sardik drum, it loses much of its fresh flavor and aroma, and the brilliant red color darkens.

Recently, tomato purée has been successfully dehydrated on the Chain Belt Company's continuous vacuum dehydrator (Figure 1) of the type now being employed for the commercial production of orange juice powder ("orange crystals"). The product is brilliant red in color, fresh in flavor and aroma and is easily reconstituted.

SPECIAL PROBELMS ENCOUNTERED IN DEHYDRATING POTATOES

1. Potato Granules

Commercial production of potato granules received early impetus from the British Food Ministry during World War II and has been under way about 10 years. Production began in America in the post-war years and expanded rapidly to meet military requirements following the outbreak of hostilities in Korea. The method used has been the "add-back" process in which a large portion of dried product is recycled by addition to freshly cooked and mashed potatoes, producing a moist granular mixture that can be dehydrated to a powder.

Figure 2 represents a flow diagram of such a process *(16)*. Raw tuber stock is washed, peeled, sliced, inspected and trimmed, cooked in steam, allowed to "steam off" (that is, carried on a belt, preferably under a hood to prevent drying, and allowed to cool), mashed, mixed thoroughly with previously dried granules, and dried with or without an intermediate holding period and secondary mix. Generally, drying is accomplished in pneumatic driers, of which several types are in use. Tray drying has also been used on a commercial scale. The dried product is screened and the small percentage that is coarser than about 20-mesh is withdrawn for use as livestock feed. The product that is packaged consists of about 15% of all the material that issues from the drier and is taken from the fraction passing through a screen of about 60-mesh. The remainder, including some of the material passing the 60-mesh screen and all of the intermediate-sized granules, is recycled as "seed" material.

There are no standard methods in the industry for these unit operations. For example, peeling can be eliminated and peel fragments removed from the dried product by screening. Steaming off and pre-mashing are omitted in some operations in which the freshly cooked potatoes are mixed with dried material continuously as they emerge from the cooker. Moisture content of this "pre-mix," type of mixer used, and duration of the period during which the premix is held before drying are known to vary. In addition to differences in the drying equipment used, there are extreme variations in drying conditions. Quality improvement and maintenance of uniformity of product are major problems in the industry.

The fluidized bed drier. As in the case of other dehydrated vegetables, the rate of deterioration because of non-enzymatic browning is greatly retarded by reducing the moisture content of the product to a low level. This can be done in a fluidized bed drier (Figure 3) without causing serious deterioration, or by first reducing the moisture level to about 5% in a fluidized bed drier and completing the moisture removal by in-package desiccation *(16)*.

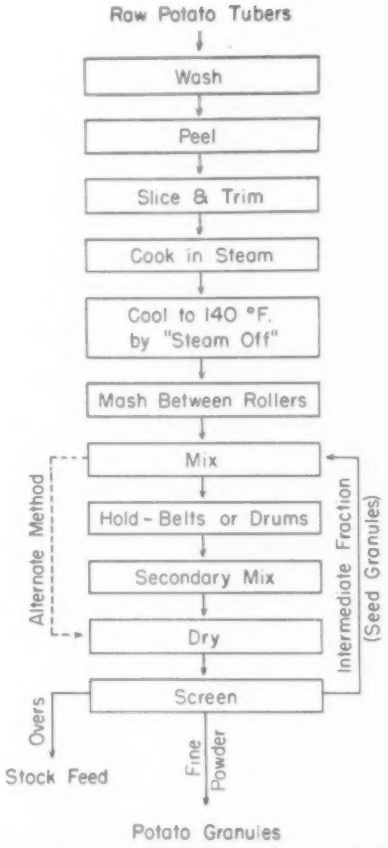

Figure 2. Flow diagram of add-back process for potato granule manufacture (16).

If an evenly distributed stream of gas is directed upward through a bed of solid particles of constant density, the force of gravity on the individual particle will be offset by friction and the particles will become suspended in the gas stream. The mass then behaves like a liquid of low viscosity. The minimum gas velocity required to "fluidize" is a function of the diameter of the largest size fraction, the relative density of the particles and the suspending gas, a roughness factor and possibly others.

Such a system is readily adaptable to the finish drying of any fine granular or powdered material. Since the fluidized mass behaves as a liquid, the process can be made continuous. Solids fed into one end of the bed fluidize immediately and gradually work their way through to the other end and discharge over a weir. The fluidizing gas transports heat into the drier, provides rapid and uniform contact with the individual particles,

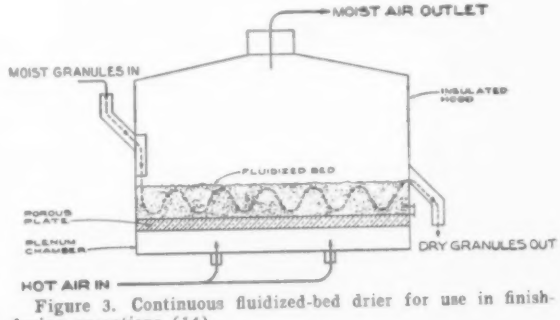

Figure 3. Continuous fluidized-bed drier for use in finish-drying operations (14).

and carries away evaporated moisture. Auxiliary heating or cooling surfaces may be installed wherever convenient and the average dwell-time of the particles in the drier can be controlled by varying the depth of bed.

A fluidized bed drier provides a method of drying which has a relatively high thermal efficiency, low power requirements, and a very gentle action, so that it finds particular use in finish drying materials which are very sensitive to impact damage at low moisture levels *(14)*. Because of its flexibility of temperature and dwell-time, such a drier is ideal for drying materials which are temperature sensitive. By using multiple units the maximum temperature attained by a particle can be held to any desired value and the dwell-time may be as long as necessary to accomplish the specified drying below the maximum temperature.

Air requirements will vary from 2-20 C.F.M. per square foot of bed and pressures will range from 2-25 inches of water in the plenum chamber depending on depth of bed and required fluidizing velocity.

The greater the reduction of the moisture level the greater the difficulty encountered in the oxidation of lipids during storage. If the moisture level is reduced below 5%, it may be essential to use an oxygen scavenger in the package if storage is to be prolonged or at a high temperature. Hendel, Burr, and Boggs *(8)* have studied deteriorative changes in sulfited potato granules (mashed potato powder) during storage. They noted the functions of moisture content, oxygen content of the package atmosphere, and type of container (permeable *vs.* impermeable). Both nonenzymatic browning and development of an oxidative off-flavor occurred slowly at 24° C. (75° F.). The latter change was accelerated (a) by lower moisture content over the range of 3.7% to 11.2% moisture, (b) by increasing oxygen content of the package atmosphere, and (c) to some extent by the use of a permeable container. The fact that both oxidative off-flavor development and oxygen absorption were somewhat retarded by petroleum ether extraction before storage indicates that the oxidative change occurs in the fat fraction of the potato.

Other problems as yet unsolved are (a) the preparation of potato granules which will give a satisfactory mashed potato regardless of the temperature of the water used, and (b) production of potato granules which can be made into mashed potatoes which will not become discolored on the steam table. The granules now commercially available produce entirely satisfactory mashed potatoes only when water at approximately 180° F. is used. Further, the product darkens slowly on standing.

2. Diced Potatoes

Problems in the production of wholly satisfactor tato dice include the following:

(a) Production of a product which does not discolor and lose its acceptability during storage particularly at temperatures above 90° F. The blanching of the potatoes in calcium chloride solution or the treatment of the blanched potatoes with a solution of a calcium salt greatly improves the stability of the dice *(17)*.

(b) There is a tendency for the potato dice to break up during handling prior to dehydration *(18)*. The treatment with calcium salts *(17)* prevents this to a large extent and permits more efficient and rapid dehydration.

(c) Potato dice, produced by conventional dehydration procedures, require soaking overnight or a 30-minute simmer for rehydration. If the cooked dice are frozen before dehydration, the rehydration is almost instantaneous.

RETENTION OF NUTRIENTS DURING DEHYDRATION AND STORAGE

Problems of Vitamin Conservation

Dehydration processes are simple, but if one is to retain the full palatability and nutritive value of the food, the problem is far more complex. In general, the methods now employed for the drying and dehydration of fruit conserve the nutritive values of the fruit well, with the exception of its vitamin C content. However, if the fruit is sulfured during process of preparation, the vitamin C content is retained, but much of the relatively small amount of vitamin B_1 contained in these products is destroyed. What is needed is some agent which will prevent the darkening of the fruit and also preserve both the vitamin B_1 and vitamin C content.

The problem of preserving the full palatability and nutritive values of vegetables during dehydration is even more difficult. During World War I, most of the dehydrated vegetables produced were lacking in flavor, texture and nutritive value. Since then we have learned that it is absolutely necessary to scald the vegetable before dehydration. Scalding not only improves the palatability of the freshly dehydrated product, but also permits the storage of the dehydrated vegetable for considerable periods without marked loss of flavor and color. It also aids materially in conserving the vegetable's vitamin content, particularly vitamin C.

Another noteworthy improvement is the dehydration of vegetables in two stages. Stage one is accomplished at a relatively high temperature (180 to 200° F.). As long as the food is moist, it will remain cool, owing to the rapid evaporation of its moisture in the rapidly moving air of relatively low humidity. When the food becomes nearly dry evaporation slows down, and the product warms up nearly to the temperature of the air. It must then be moved over into another part of the dehydration equipment in which the second stage of dehydration is carried out. The latter is effected at a point somewhat under the so-called "critical temperature" for the vegetable being dehydrated. With onions, this temperature is about 140° F. The critical temperature of cabbage and sauerkraut is approximately 145° F. Some other vegetables—for example, beets—may be finished at a temperature as high as 165° F.

In general, properly scalded dehydrated vegetables prepared under optimum conditions retain all of their nutritive values well, with the exception of vitamin C. Work carried out at the New York State Agricultural Experiment Station *(21, 22)* determined the losses of vitamins occurring during commercial dehydration of cabbage, rutabagas beets and potatoes. Relatively small losses of carotene and thiamin and large losses of ascorbic acid were observed. The data are summarized in Table I.

Researches now in progress promise to reveal how vegetables may be prepared and dehydrated without marked loss of vitamin C. Preliminary studies seem to show that if the vegetables are scalded with superheated steam or steam under pressure, a much higher percentage of the vitamin C is retained than if the product is scalded in boiling water or ordinary live steam.

VITAMIN LOSSES DURING STORAGE

Most freshly dehydrated vegetables are of high quality, comparable in color and flavor to the original vegetable, but, if the moisture content is not reduced to 1% or lower, they gradually decrease in flavor, color, and vitamin content during storage. In some instances, off-flavors develop and the product turns dark. Onions,

TABLE 1

Loss of vitamins during commercial dehydration of vegetables in cabinet dehydrator (21, 22)

Vegetable	Dry Matter Basis								
	Fresh			After dehydration			Percent loss during dehydration		
	Carotene μg. per g.	*Thiamin* μg. per g.	*Ascorbic acid* mg. per g.	*Carotene* μg. per g.	*Thiamin* μg. per g.	*Ascorbic acid* mg. per g.	*Carotene*	*Thiamin*	*Ascorbic acid*
Cabbage	(a)	5.92	4.40	(a)	5.60	3.56	(a)	5.4	19
Rutabagas	39.6	7.07	3.16	36.0	5.89	0.42	9.0	16.7	87
Beets	(a)	2.40	0.24	(a)	1.93	0.17	(a)	19.5	29
Potatoes	(a)	6.17	0.76	(a)	4.75	trace	(a)	24.6	100

(a) Not determined—little carotene was present in the original fresh vegetable.

cabbage, carrots and sweet potatoes deteriorate in storage somewhat more rapidly than the other vegetables commonly dehydrated. At ordinary room temperatures, for example 70° F., the rate of deterioration is relatively slow. Thus, even the products listed above retain their quality for 6 to 9 months. If, however, the temperature is raised to 90 to 100° F., the loss of quality is very rapid, particularly in the case of the four vegetables named. If these products are packed under carbon dioxide or nitrogen, their palatability, color and vitamin content are retained somewhat longer.

Storage losses of carotene and ascorbic acid are much greater than those of other vitamins. Thiamin losses are negligible. Refrigeration aids in retarding losses of both carotene and ascorbic *(22)*, but the temperatures must be very low if the losses are to be reduced to a minimum (Table 2).

The lower the moisture content, the slower the rate of loss of quality and vitamins at any given temperature *(3)*. However, it is difficult to remove the last few percent of moisture from these vegetables unless in-package desiccation is used.

From the foregoing, it will be seen that, if dehydrated vegetables are to be stored for a considerable period of time, it is important first to reduce the moisture content to the lowest level practicable and then to store the products under refrigeration. If these precautions are taken, any of the dehydrated vegetables can be maintained in excellent condition for a year and many of them for 3 years or longer. Further, little loss of ascorbic acid will occur during storage.

Work at the Sardik Laboratories *(5)*, and at Western Utilization Research Branch, U. S. Department of Agriculture, has shown that the lower the moisture level the better ascorbic acid is retained in dehydrated tomato "flakes" and orange juice powder (Figures 4 and 5). When in-package desiccation was used *(9)*, little loss of ascorbic acid occurred during 6 months' storage at either 70° or 100° F. (Figure 5).

TABLE 2

Ascorbic acid content of stored dehydrated rutabagas (22)

Period, months	How stored	Storage temperatures			
		−40° F.	33° F.	58° F.	75° F.
			mg. per g.		
0		0.42	0.42	0.42	0.42
1	In air in glass container	0.32	0.47	0.28	0.36
	In cellophane bag	0.47	0.47	0.36	0.38
	In CO_2 in glass container	0.38	0.60		0.39
2	In air in glass container	0.27	0.45	0.43	0.26
	In cellophane bag	0.34	0.55	0.26	0.24
	In CO_2 in glass container	0.34	0.36		0.35
3	In air in glass container	0.38	0.35	0.37	0.31
	In cellophane bag	0.44	0.40	0.38	0.43
	In CO_2 in glass container	0.43	0.46		0.34
4	In air in glass container	0.41	0.21	0.18	0.16
	In cellophane bag	0.38	0.26	0.19	0.19
	In CO_2 in glass container	0.42	0.34		0.17

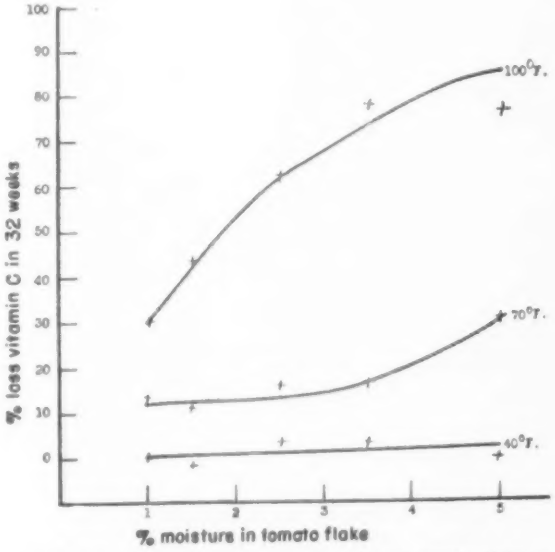

Figure 4. Effect of moisture in dehydrated tomato flake on vitamin C loss (4).

SUMMARY

Great strides have been made in the development of dehydrated vegetables, fruits, and fruit juices of excellent quality which retain their flavor, aroma, color and texture during storage for 2 years at 70° F. or 6 months at 90° to 100° F. The list of satisfactory dehydrated products now includes the following: apples, orange powder, grapefruit juice, tomato powder, potato granules, diced potatoes, onions, peppers, green beans and sweet corn. It is hoped that pineapple juice powder, green peas, lima beans and cabbage will be added to the list in the near future.

These advances have been brought about principally by certain improved techniques, as follows: (a) Sulfuring; (b) Reduction to very low moisture content by in-package desiccation; (c) Use of low temperatures for dehydration, e.g., puff drying in high vacuum.

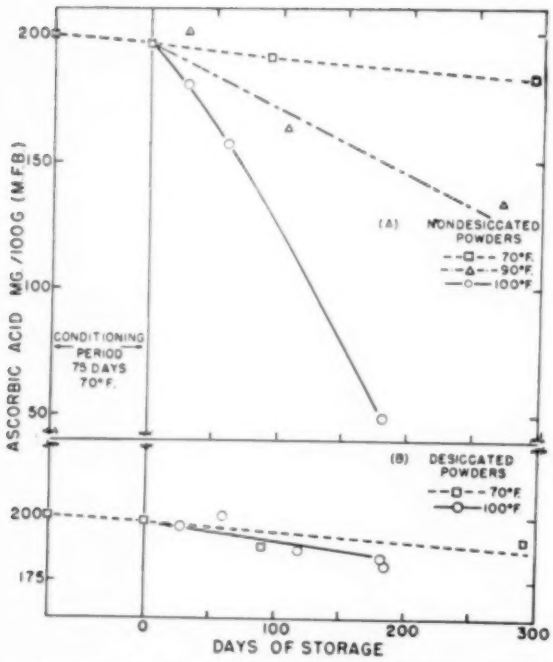

Figure 5. Effect of in-package desiccation upon ascorbic acid content of non-sulfited air-packed orange-juice powder stored at 70°, 90°, and 100° F. (13).

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Color Changes in Strawberry Jellies[a, b]

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Changes in color and pigment content of strawberry jellies were studied as functions of the amount of heat applied in processing and in storage. A high degree of correlation was obtained between loss in brightness, heat applied, pigment retention and ultraviolet absorption due to sugar degradation; 140° F. (60° C.) was found to be the highest temperature below which there was no appreciable loss in pigment content in cooking. Initial color gains achieved through the use of sugared, frozen strawberries and/or vacuum concentration were rapidly lost when products were stored at 100° F. (37.7° C.).

The discoloration of strawberry products has been the subject of extensive research in recent years by a number of investigators, including Kertesz and Sondheimer *(4, 5, 6, 13, 14)*, Mackinney and Chichester *(11)* and Meschter *(12)*. It is well established, therefore, that color changes in stored strawberry products are caused by chemical degradation processes involving pigment and carbohydrate constituents. In a previous contribution *(9)*, Livingston *et al.* reported on exploratory experiments to determine the effect of heating and storage on model systems of the carbohydrate fraction, i.e. sugar-acid-pectin gels. It was determined that gels could darken visibly when subjected to thermal processes nearly comparable to those in preserve-making by the open kettle method. This darkening, which can continue in storage, was affected by the type of sugar used, acidity of the gel, and the presence or absence of ascorbic acid.

The present paper is concerned with some quantitative aspects of color changes in strawberry jellies, including the effects of (a) processing time-temperature relationships, (b) storage conditions, and (c) selected additives on pigment destruction, ultraviolet absorption, and loss of brightness.

EXPERIMENTAL

Procedure for making strawberry jelly. Strawberries of various varieties cultivated at the University of Massachusetts were frozen without sugar and held at 0° F. (−17.8° C.) until used. The pigment content of the individual varieties is listed in Table I. The frozen berries were thawed out, and the juice extracted by a hand wine press. The metallic parts of the press were coated with paraffin to prevent contact of the juice with metals. The juice was deaerated by passing nitrogen through it for 30 minutes, filled into gallon jugs, and held frozen at 0° F. (−17.8° C.) until needed.

A vacuum concentrator[d] was used in preparing the jelly. The strawberry juice containing the sugar was concentrated under a vacuum of 28 to 29 inches at a temperature not exceeding 140° F. (60° C.). The pectin, dissolved with sugar in water, was added toward the end of the evaporation. When a solids content of 63 to 65% was attained, the concentrate was drawn into a large flask, the acid added, and the jelly placed into a hot water bath until a temperature of 180° F. (82.2° C.) was reached and maintained for 10 minutes. The jelly was then dispensed into clean six-ounce glasses, cooled in running tap water, and covered with paraffin and metal caps.

In order to facilitate the handling of samples in the experiments dealing with the effects of thermal processing, jellies of lower viscosity than those resulting from the above procedure were desired. Consequently, only one-fourth (about 0.1% instead of about 0.4%) of the usual amount of pectin was added during the preparation of the jelly samples for this phase of these studies, yielding a viscous liquid rather than a gel.

TABLE I

The pelargonidin 3-monoglucoside content of strawberry varieties grown and frozen at the University of Massachusetts during the 1953 season, and used in this study

Variety	mg. percent of pelargonidin 3-monoglucoside in	
	drained berries	drained juice
Armore	17.9	9.5
Catskill	28.5	14.3
Eden	33.6	16.7
Erie	22.9	11.1
Great Bay	32.8	13.2
Howard	30.7	16.1
June Rockhill	24.5	14.0
Pathfinder	28.8	18.1
Robinson	28.2	9.9
Sparkle	37.8	16.9
Temple	24.3	11.7
Vermillion	23.7	15.0

Heat processing. Jellies were filled into 18 x 150 mm. Pyrex test tubes, which were evacuated, filled with a nitrogen headspace, and sealed in an oxygen flame. The tubes were heated for the times indicated by immersion in an oil bath equipped with a deKhotinsky thermo-regulator. At the end of the heating period, the tubes were rapidly cooled in an ice water bath.

Pigment analysis. The method of Sondheimer and Kertesz *(13)* for the determination of pelargonidin 3-monoglucoside was used throughout. According to these authors, an average deviation of about 7% is not excessively high.

Ultraviolet analysis. As an indication of the extent of sugar degradation and resulting formation of breakdown products absorbing in the ultraviolet range, the optical density of the jellies was determined at 285 mμ using a Beckman DU Spectrophotometer.[e] A weighed amount of jelly was quantitatively diluted with water, filtered, and its optical density measured in the sensitive range of the spectrophotometer scale. The reading obtained was then multiplied by the proper dilution factor.

Determination of C.I.E. brightness. The Beckman DU Spectrophotometer, equipped with a reflectance attachment was used. Jelly samples were placed in a shallow, white enameled, cuvette measuring 40 mm. in diameter and 9 mm. in depth, which was covered by a glass slide to present a reproducible sample thickness. A Vitrolite standard, prepared by the National Bureau of Standards, was used to calibrate the instrument at each wave length in terms of a freshly prepared magnesium oxide surface. C.I.E. brightness was calculated from the spectral reflectance data by means of the selected ordinate method *(3)*. The use of

[a] Presented at the Fifteenth Annual Meeting of the IFT at Columbus, June 15, 1955.

[b] Contribution No. 1003, Massachusetts Agricultural Experiment Station. This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 583 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

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[d] Manufactured by Precision Scientific Co., Chicago, Ill.

[e] Manufactured by Beckman Instruments, Inc., South Pasadena, Calif.

this value as a measure of color in strawberry jellies has been suggested by Mackinney *(10)*.

RESULTS AND DISCUSSION

Processing studies. Meschter *(12)* demonstrated the logarithmic nature of color loss in strawberry juice and pigment extracts. Similar destruction rates for the pigment in jellies were obtained in the present study as indicated in Figure 1. Since time lags in heating and cooling are unavoidable, even in the processing of samples contained in test tubes, heat penetration data on the jelly tubes were obtained. A Leeds and Northrup potentiometer, reading directly in degrees Fahrenheit, was connected to a 24-gauge copper constantan thermocouple sealed into the sample tube. Using a planimeter on the resulting heating-cooling data, it was possible to express thermal treatments in terms of "temperature summations," i.e., degrees Fahrenheit above a base temperature multiplied by minutes at each temperature. To determine the proper base temperature to be used, the correlation between percent color loss and temperature summation was calculated for different base lines for oil bath temperatures ranging from 180°

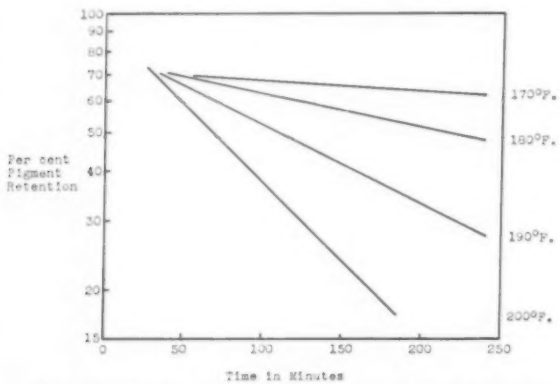

Figure 1. The effect of time at different processing temperatures on the pelargonidin 3-monoglucoside content of strawberry jelly at pH 3.0.

to 240° F. The following correlation coefficients were obtained: for a base line of 160° F.—0.9931; for 140° F.—0.9894; for 120° F.—0.9980; for 100° F.—0.9973. The temperature of 140° F. was therefore selected as the highest one below which there was no appreciable loss of pigment in cooking.

The effect of thermal processing on the pigment content, ultraviolet absorption and brightness of strawberry jellies at pH 2.9 is shown in Table 2. Highly significant correlation coefficients were obtained between temperature summations and pigment loss or brightness as well as between brightness and pigment loss or ultraviolet absorption. (Table 3.)

An analysis of the data indicates that the pigment loss or reduction in brightness varies with processing temperatures as well as with the temperature summation. Thus, in Figure 2, it is apparent that a given temperature summation results in greater color loss as the bath temperature increases. This is in accordance with the findings of Kramer and El-Kattan *(7)* for color loss

TABLE 2

Effect of thermal processing on the anthocyanin content, optical density at 285 mμ and brightness of strawberry jellies at pH 2.9

Temperature (° F.)	Time (min.)	Temperature Summation[1]	Pigment (mg. %)	Optical density at 285 mμ	C.I.E. brightness
	0	0	5.42		9.58
170	55	588	4.04	0.174	7.61
	110	1250	4.00	0.202	7.24
	220	2485	3.50	0.303	6.75
	440	5015		0.336	5.53
180	50	700	3.95	0.177	7.45
	100	1450	3.53	0.232	6.88
	176	2500	2.72	0.265	6.29
	400	5860	2.03	0.502	4.86
190	45	793	3.75	0.203	7.36
	90	1648	3.33	0.260	6.76
	217	3206	2.05	0.490	5.29
	370	6113	1.19	0.834	4.24
200	40	853	3.59	0.248	7.20
	80	1777	2.75	0.358	6.33
	160	3613	1.77	0.698	5.03
	320	7293	0.88	1.392	3.62

[1] 140° F. base temperature.

in tomato products. It should, however, be pointed out that this does not necessarily imply that a greater color retention is to be expected at the lower temperatures when strawberry products are given a thermal process of equivalent microbiological value. For example, when the data presented here are evaluated in terms of the requisite process for the heat resistant mold isolated from canned blueberries by Williams, Cameron, and Williams *(15)*, it becomes evident that greater color destruction would ensue at the lower bath temperatures due to the extreme times which would be required for destruction of this organism.

Several additives were tested for their effect on the rate of pigment destruction in processing. Their effectiveness was determined by heating jellies containing these additives at several bath temperatures, drawing samples at different time intervals, and analyzing them for the anthocyanin pigment. From the data obtained, the half-life of the pigment under each set of conditions was determined by using the regression equation:

$$\log \hat{Y} = \bar{y} + b\,(X - \bar{x})$$

where $\bar{x}$ is the mean of the exposure time in hours, $\bar{y}$ is the mean of the logarithm of percent pigment retention, b is the slope of the regression line, and X is the half-life value obtained by giving $\hat{Y}$ the value of 50%. The results are presented in Table 4, where it is apparent that the additives had but a minor effect on the destruc-

TABLE 3

Correlation between temperatures summations and brightness or pigment loss, and between brightness and pigment loss or ultraviolet absorption in strawberry jellies at pH 2.9

Variables	Correlation coefficent			
	170° F.	180° F.	190° F.	200° F.
Temperature summation and brightness	0.999	0.990	0.974	0.981
Temperature summation and pigment loss	0.995	0.965	0.967	0.955
Brightness and pigment loss	0.988	0.985	0.999	0.996
Brightness and ultraviolet absorption	0.992	0.983	0.979	0.971

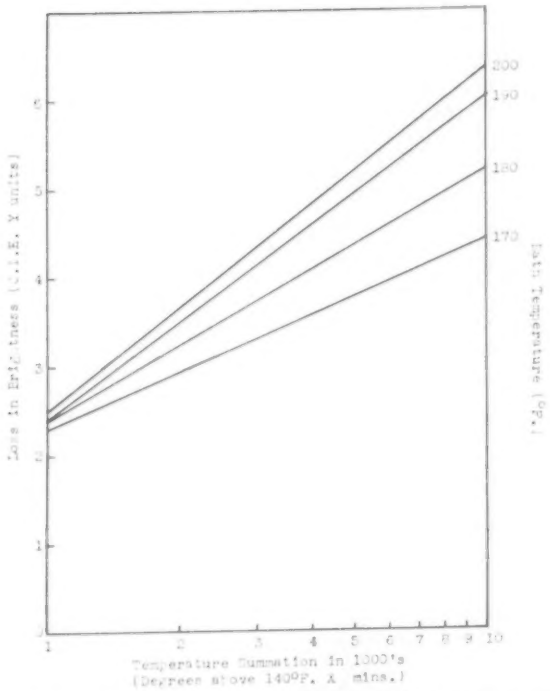

Figure 2. Regression lines showing loss in brightness of strawberry jellies (pH 2.9) at different bath temperatures.

tion rates of the pigment at processing temperatures.

Storage studies. The value of vacuum concentrating strawberry preserves as opposed to the open kettle method is well established. When frozen strawberries are used, the cooking time is shortened and a better color can be obtained. It was, however, of interest to determine whether the initial color advantages resulting from vacuum processing and the use of the frozen fruit would be retained in storage. Table 5 shows that storage at 100° F. (37.7° C.) is equally destructive in all instances. Visually, the onset of browning tends to mask what little differences do exist in color due to the anthocyanin present.

The extent of pigment loss and sugar degradation in storage is indicated in Table 6. Triangular difference taste tests under subdued illumination were also conducted on samples of strawberry preserves made from fresh strawberries and stored at 100° F. (37.7° C.) and 34° F. (1.1° C.). It was evident from the response of the panel that changes in the flavor of the preserves increase with color loss. The ability of the panel members to discriminate between samples held at 100° F.

TABLE 4

The effect of heating temperatures and additives on the half-life of pelargonidin 3-monoglucoside in processing

Additive	Half-life, in hours, at		
	200° F.	220° F.	240° F.
None	1.38	0.73	0.28
Kojic acid (0.05%)	1.39	0.75	0.26
Quercetin (0.076%)	1.71	0.65	0.26
Rutin (1.0%)	1.66	0.76	0.31
Sequestrene (0.076%)	1.32	0.67	0.23
Thiourea (.076%)	1.49	0.67	0.28

TABLE 5

Pigment retention in strawberry jelly and preserves stored at 100° F. (37.7° C.)

Days storage	Pigment retention (%)		
	Jelly (vacuum concentrated)	Preserve (made in open kettle) from	
		fresh fruit	frozen fruit
0	100	100	100
5	65		
7	56		52
13	36		
14		30	
19	26		
21		34	22
22	18		
35		22	
Initial Pigment Content (mg. %)	5.4	8.5	11.5

and those stored at 34° F. increased with the length of the storage period (after 2 weeks, only 35% of the judges were able to correctly segregate the samples; after 3 weeks, 44%, and after 25 weeks, 60%.) It is obvious from the data contained in Table 6, as it is from an organoleptic standpoint, that were it economically feasible for strawberry preserves to be stored at refrigerator temperatures, the shelf-life of such products would be materially extended.

The effect of several additives on color retention in storage was also determined. Dextrose, levulose and β-lactose were substituted for a portion of the sucrose in some of the samples, and their effect on the half-life of the pigment at 100° F. determined. One sample of jelly was prepared, using 20% cranberry juice, by weight, since a strawberry-cranberry jam containing 25-30% cranberry solids has been found to stand up well for 6 months at 100° F. (38° C.) *(1)*. The juice used in this study was extracted from Howes cranberries. In view of the results reported by Hall *(2)* with phosphates added to strawberry products, a strawberry jelly was prepared which contained 3 ml. of a phosphate solution (20 g. of trisodium phosphate and 20 g. of disodium phosphate dissolved in water and diluted to 100 ml.) per pound of strawberry juice, giving a final concentration of 0.15% by weight. Results of these experiments are summarized in Table 7. It is apparent that only the sugars were able to increase somewhat the half-life of the pigment at 100° F. The fact that substitution of some sucrose by glucose might aid in slowing down pigment breakdown had been anticipated, since the reactivity of fructose and its degradation products is well known *(8, 9)*. It is, therefore, all the more surprising to find that the half-life

TABLE 6

Effect of storage on percent pigment retention and optical density at 285 mμ in strawberry jellies

Time (days)	Storage temperature					
	34° F.		85° F.		100° F.	
	Pigment	O.D.	Pigment	O.D.	Pigment	O.D.
0	100	0.260	100	0.260	100	0.260
7					56	0.267
13			65		36	
22			43	0.313	18	0.338
64	71	0.265				
256	49	0.265	3	0.338	0	2

TABLE 7

Half-life of pigment in stored strawberry jelly containing various additives.

Additives	Half life at 100° F. (in days)
None	8.5
Dextrose (16.25%)	9.8
Dextrose (65%)	11.6
Levulose (12.2%)	13
β-Lactose (14.5%)	13
Phosphate (0.15%)	8.3
Cranberry Juice (20%)	6.4

of the pigment was somewhat increased in the presence of levulose. It should be pointed out, however, that the destruction rate of the pigment is not necessarily a criterion of color change, since fructose is far more reactive than the other sugars in promoting browning which soon masks the color due to the pigment present.

It is of interest that the half-lives for pigment destruction obtained through storage at 100° F. (37.7° C.) were usually larger than those obtained through extrapolation of the logarithmic destruction rate drawn from data gathered at processing temperatures. For example, a value of 1.8 days for the half-life at 100° F. was extrapolated from pigment destruction data obtained in the range of 180° F.-240° F., and a value of 7.9 days from data in the 170° F.-200° F. range, as compared to 8.5 from actual storage data at 100° F. Although this can only be attributed to the magnification of experimental errors through logarithmic extrapolation, it does seem to point out the danger of using destruction data obtained at the higher temperatures (i.e., accelerated conditions) as a basis for accurately estimating product shelf-life.

SUMMARY AND CONCLUSIONS

The effects of thermal processing, storage, and a number of chemical additives on color retention in strawberry jellies were determined.

Excellent correlation was obtained between thermal treatment, expressed as temperature summation, and pigment loss or brightness loss. Brightness was also correlated to pigment loss and ultraviolet absorption due to sugar degradation. Equivalent temperature summations resulted in greater pigment or brightness loss at higher processing temperatures, but this does not necessarily reflect on the degree of color loss that would result from the application of microbiologically equivalent heat treatments.

Kojic acid, quercetin, rutin, sequestrene, and thiourea tested as additives were found to have only minor effects on the rate of pigment destruction in processing. Destruction of pigment at 100° F. (37.7° C.) was equally rapid in preserves made from fresh or frozen fruit.

Only temperature exerted a significant effect on the pigment stability in stored jellies. Changes in sugar composition or the addition of phosphates or cranberry juice did not greatly influence pigment half-life at 100° F.

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Experimental Production of Tomato Powder by Spray Drying

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Noncaking tomato powder of good quality and high bulk density has been produced experimentally by spray drying. Production required substantial deviations from the usual design of commercial spray driers, establishment of specific operation procedures, and careful control of the composition and properties of the tomato concentrate used as a starting material. The powder may prove useful for remanufacture in dehydrated soups and other prepared products.

Few commodities processed for food use are as high in water content as tomato. The consumer must bear the cost of package, storage, and freight on roughly 15 pounds of water for each pound of tomato solids in "single strength" juice or solid pack. Concentrates such as pastes or catsup have had three-fourths or more of their water removed, yet 2 to 3 pounds of water remain for each pound of solids. Because of the very heavy consistencies of high-solids tomato concentrates, further reduction by evaporation becomes very difficult in standard equipment. Further, high-solids concentrates undergo changes in storage, particularly at temperatures encountered in warm-climate areas *(9)*.

Dry powdered tomato allows reduction in package and distribution costs which partially offset its higher production cost. Outlet for the powder may be found in both civilian and military markets. Dry mixes for soups, sauces, and gravies are potential products. Use of the powder for making beverage juice may be developed as an additional outlet. In some respects tomato powder may offer advantages over paste for remanufacturing use.

A process for the production of tomato powder by vacuum drying *(4, 11)* has been developed at this laboratory. Investigations designed to improve processing methods, reduce production costs, and evaluate storage stability are now under way. The vacuum-dried powder appears very promising. Tests on spray drying of tomato in improved equipment were encouraging also. Investigations of this process were initiated to determine whether spray drying offers advantages over the vacuum drying method.

Various workers have explored the fundamentals of spray drying to establish rational elements of design. Work has been done on the mechanism of atomization *(1, 2, 6)*, heat transfer to small particles *(3, 7)*, particle trajectories *(5)*, and on other phases *(10)*. The drying systems evolved have been diverse and numerous. Many have never operated with complete success. All installations are limited in application, especially laboratory or pilot-plant models. Small size introduces difficulties that often do not arise in larger equipment and also allows less flexibility. When a developmental spray-drying operation is transferred to full-scale equipment, differences are usually in the direction of improvement. However, tests on available full-scale driers should be made whenever possible before construction of large and costly driers is planned.

Special precautions are required in the production of spray-dried tomato powder since the product particles are very hygroscopic and readily become sticky under conditions of high relative humidity or high temperature. As a result of high hygroscopicity, the moisture content of the product is greatly influenced by collection-zone humidity conditions. Not only must conditions be carefully controlled to avoid scorching and sticking in the drying zone, but conditions in the collection zone must be controlled to prevent sticking to equipment and regain of moisture. The range of permissible operating conditions, based on physical data for the powder, appears to be quite narrow. However, drying can be satisfactorily accomplished under conditions that are seemingly unfavorable by applying procedures developed in the present work.

EXPERIMENTAL EQUIPMENT

Initial tests were made in an existing spray drier (Figure 1) which proved unsatisfactory. This unit is large for an experimental model. The diameter is 7 feet, 8 inches; the vertical walls are 15 feet high and surmount a 60° cone, 5½ feet high. This drier was intended to operate so that the heated air and atomized feed travel in the same direction. In this manner the product is exposed to the hottest air when moisture levels are high, and to cooler air when moisture levels are low, thus minimizing scorching. The feed was atomized by a pressure spray nozzle located just below a hot-air-inlet "gun" at the top of the drier. A rotary motion was imparted to the entering hot air by a set of stationary vanes in the "gun." The cold-air inlets consisted of dampered slots in the walls of the drying chamber. Atmospheric air was admitted tangentially in controlled amounts at one or more of three different levels. The theory was that atomized feed would be thrown outward by the

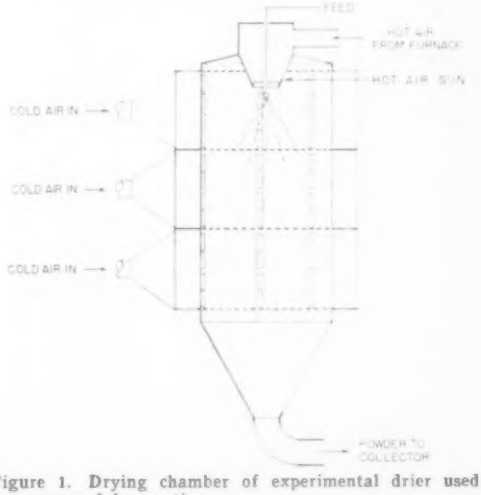

Figure 1. Drying chamber of experimental drier used in early unsuccessful operations.

spin of the air, so as to be first flash-dried and then flash-cooled. The cool walls would aid in preventing deposits.

Although this drier was suitable for milk and other easily-dried materials, it could not be used to produce satisfactory tomato powder. Reasons for failure include the following: (a) The diameter of the drying chamber was too small, (b) the blast of hot air carried incompletely dried droplets down too rapidly, (c) the turbulence caused by the entering cold air was so great that the drying zone was chilled too much for effective drying action, (d) wet particles were thrown outward into the cool annulus, and (e) sanitation was poor because some of the product lodged in the annular plenums.

Modifications found necessary are shown in figure 2. The cold-air-inlet slots were sealed and in their place 8 diffusers (22 inches long, with 3-inch-diameter inlet and 4-inch-diameter outlet) were installed, evenly spaced about the lower part of the drying chamber and directed downward along the face of the cone. The hot-air-inlet "gun" was replaced by a 33-inch-diameter perforated sheet-metal opening. The hot-air-inlet flow pattern was thereby changed from rotary to straight-line. The modifications were limited to those feasible on the existing unit; certain desirable changes, such as an increase in diameter of the drying chamber, could not be made.

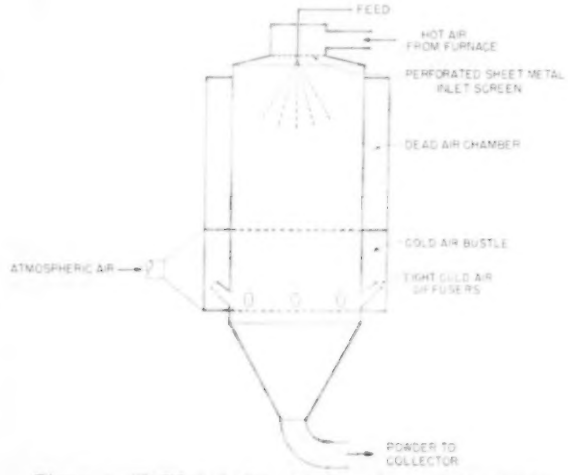

Figure 2. Modified drying chamber of experimental drier used for production of tomato powder.

The system for feeding the drier included, in the order indicated, (a) a 5-gallon conical-bottom paste tank mounted on the platform of a dial-reading scale and a 25-gallon parallel-connected water feed tank, with valves so that either water or paste could be used, (b) a half-inch I.P.S. high-suction pump (used as a booster, to feed the high-pressure pump), (c) a homogenizer-pump, operable at pressures up to 5,000 p.s.i., and (d) a pressure-type spray-nozzle, fitted with an 0.055-inch orifice and a rotary-type core.

The drying chamber (Figure 2) was connected by an 18-inch-diameter insulated duct to a 6-foot-diameter conventional cyclone-type collector, where the dry powder and the humid exhaust air were separated. The product fell into a powder aspirator (Figure 3) and was conveyed by a stream of warm dehumidified air to a 16-inch-diameter final collection cyclone (Figure 4). All parts that contact feed paste or dry powder were stainless steel, neoprene, or glass.

Atmospheric air used for drying was heated by a gas-fired indirect-heating furnace, manually controlled. The spent drying gases were exhausted by a fan with a maximum capacity of approximately 5,000 c.f.m.

PROCEDURES

Feed preparation and composition. The feed stock, a commercial pack, contained 30% total solids. Careful selection was

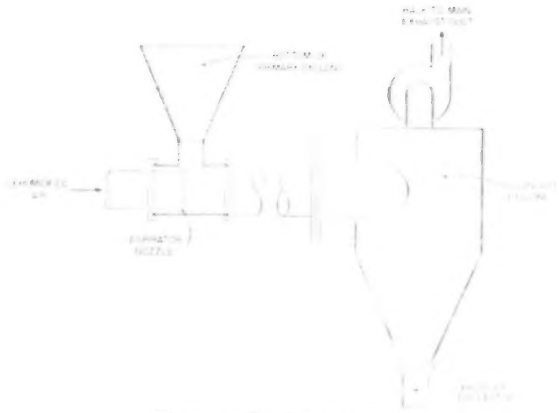

Figure 3. Powder aspirator.

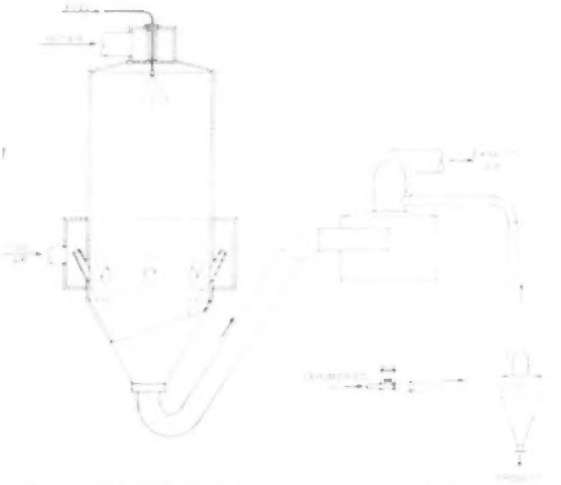

Figure 4. Experimental drier, and powder conditioning and collecting system.

made of "hot-break" (high-pectin) paste which had been finished on an 0.035-inch screen. Removal of coarse pulp, skin, and fiber reduced the hazard of plugging the spray nozzles during operation.

A solution of sodium chloride and sodium bisulfite in the proper proportions was added to adjust the feed paste to 20% tomato solids, 2% sodium chloride (the usual proportion in beverage juice), and 200 p.p.m. SO_2, all on the wet basis. The paste was mixed gently, to avoid inclusion of air, with a wire-whip mixer. The mixture was homogenized to promote good atomization and reduce plugging of spray nozzles.

Operating procedures. The drier was operated with water feed until thermal equilibrium was obtained and then switched to tomato paste feed. Rates of feed were established from scale readings at measured intervals. The feed tank was refilled as required.

Air samples for humidity measurements were continuously drawn off during a run, through a manifold which allowed selection of the sampling point. Sampling points were: atmosphere, first cyclone, second cyclone, and dehumidified air. Electric heating was used on the air sampling line leading from the first cyclone to prevent condensation of moisture.

Temperatures were measured and/or controlled at 5 points: hot-air venturi, hot air at inlet to drying chamber, primary cyclone, secondary cyclone, and dehumidified air.

Hot and cold air flow rates were measured by venturi meters. An orifice meter was used for measurement of the dehumidified air flow rate.

The powder aspirator required approximately 20 pounds per minute of dehumidified air (0.001 to 0.003 pound moisture per pound of air). Heat was supplied through automatically controlled steam heaters; the maximum air temperature in this work was approximately 110° F.

Adjustment in powder aspirator operation was made so that a minimum of humid air from the first cyclone was drawn along with the powder. The flow of dehumidified air was controlled to obtain approximately one-half inch (w.g.) suction at the vena of the aspirator.

Analytical procedures. Measurements of air humidity were made with a dew-point potentiometer developed and constructed at this laboratory, which will be described in a later publication. This instrument is capable of measurement of dew points to within ±0.5° F., in the range 10° to 100° F.

Moisture determinations on the powder were made by a 16-hour, 60° C., vacuum-oven method. Total solids measurements on the tomato paste were made by N.C.A. methods *(18)*.

Relative humidity of air in equilibrium with tomato powder was determined by exposing a thin layer of powder in a dish in a desiccator containing another dish of sulfuric acid of known concentration. The desiccator containing the tomato powder and the acid was held at constant temperature for 3 to 10 days, depending on the temperature, until equilibrium was attained. The tomato powder and the acid were then analyzed for moisture. Relative humidity was readily calculated from available data for sulfuric acid.

Sticky-point temperature was determined empirically. A test tube containing sample material was immersed in a water bath while temperature of the bath was slowly raised. The powder was lightly compacted by tamping with a small propeller and stirred by intermittently rotating the propeller ¼ turn. The sticky-point temperature was defined as the bath temperature at which the force necessary to turn the stirrer increased sharply.

Bulk densities were determined by weighing 250 ml. of powder loosely poured into a graduated cylinder. Packed densities were determined by firmly tapping the cylinder of powder until no further change in volume occurred.

RESULTS AND DISCUSSION

Effects of hygroscopicity and sticky point. The relative humidity of air in equilibrium with spray-dried tomato powder (Figure 5) is independent of temperature in the range of conditions covered in these measurements. Tests were not made at lower temperatures, but Figure 5 is probably representative at temperatures below 100° F. Decomposition of tomato powder prevents use of the present method above 150° F.

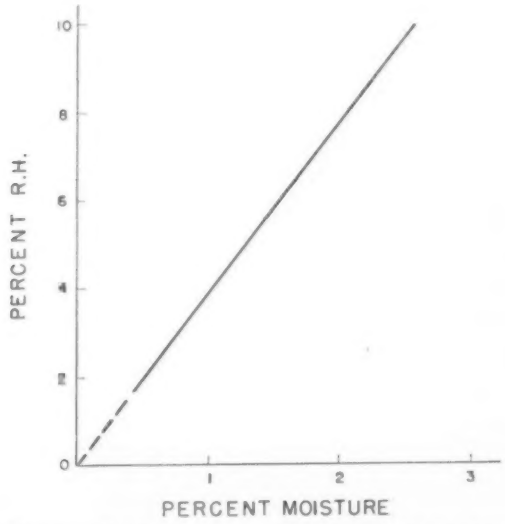

Figure 5. Moisture content vs. relative humidity for tomato powder at equilibrium. Temperature range 100-150° F.

The sticky-point temperature for a given tomato powder is an inverse function of moisture content. Sticky-point temperatures can be expected to vary among lots of tomato. Figure 6 shows a typical curve.

Figures 5 and 6 indicate that tomato powder of approximately 2% moisture content cannot be exposed to conditions above 140° F. and 7% R.H. (0.009 absolute humidity) without becoming sticky. From these data it *appears* impractical to spray-dry tomato, since the absolute humidity of atmospheric air is frequently 0.009 or higher.

Although these data (Figures 5 and 6) would appear to discourage any efforts to spray-dry tomato, there are

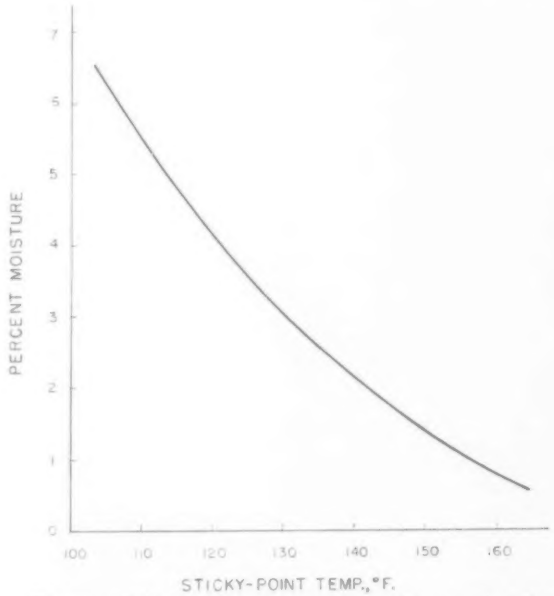

Figure 6. Sticky-point temperature vs. moisture content for spray-dried tomato powder (typical curve).

means by which stickiness can be prevented—e.g., by sharp chilling at the point at which the particles are at the desired moisture content. A consideration of rates of heat and moisture transfer will explain why sharp chilling accomplishes the desired effect. When a droplet of tomato paste is injected into a stream of heated air, the heat-transfer potential is high and evaporation of water is rapid. The temperature of the droplet does not at first rise much above the wet-bulb temperature of the air (e.g., approximately 115° F. for air at 400° F. dry bulb). As drying continues, the temperature of the particles increases sufficiently to maintain a sticky condition. However, if the dried particles are sharply chilled by introducing cooler air, a nonsticky shell is formed, and the powder can then be briefly conveyed in the cooled airstream without adhering to solid surfaces or to each other. However, in this new air stream, relative humidity is at a higher level and the

suspended hygroscopic particles readily pick up moisture and will become sticky again unless they are quickly transferred to a low-humidity atmosphere. It was found that conditions of humidity which exceed the limits shown in Figure 5 can be tolerated in the cooling and collecting zones provided long contact of the powder with the exhaust air is avoided. Thus drying capacity was increased to a more practical level than anticipated from the data given in this figure.

Drying capacity was further increased by shortening retention time and employing higher hot-air temperature in the drying zone than was at first believed practical. However, it appears that any spray-drying system designed to produce tomato powder will be larger and more costly than systems of comparable capacity designed to spray-dry nonsticky materials.

Operating conditions. In a series of runs the experimental unit was used to produce several hundred pounds of powder for storage studies. To avoid delay in the storage tests, these runs were made before it was possible to undertake studies on optimum operating conditions and capacity. The conditions selected, which were satisfactory for the purpose, were approximately as follows: (a) Hot air inlet temperature, 405° F., (b) feed rate, 4 lbs. per minute (22% total solids, 2% NaCl, 200 p.p.m. SO_2), (c) hot air flow rate, 160 lbs./min., (d) atmospheric secondary air, 140 lbs./min. (0.004 to 0.009 lb. H_2O/lb. dry air), (e) dehumidified air, 20 to 22 lbs./min. (0.002 lb. H_2O/lb. dry air), (f) primary cyclone temperature, 165° F., and (g) secondary cyclone temperature, 110° F.

The yields obtained under these conditions were 60 to 65%. Product moisture content was 2%. Each run averaged about 2 hours. No provision was made to remove wall deposits continuously during a run, but the deposits appeared to be loose and dry and were readily brushed or scraped off.

Wall deposits. Wall deposits appear to be attributable to inadequate drying of large particles. Calculations indicate that the *retention* time of sprayed particles in the hot zone of the drier ranged from 2 to 5 seconds. In this time range, particles of all sizes must be sufficiently dried if stickiness after "quenching" in the cool zone is to be avoided. Obviously, small and large droplets will not dry to the same degree in a given time under the same conditions. Conditions which cause scorching of small particles may still allow large droplets to remain too moist.

Two sources of data were used for estimating the *drying* times for spray droplets. Johnstone *(3)* studied heat transfer to small solid particles suspended in a hot air stream. For 200 μ particles of sand, convection heat-transfer coefficients were in the order of 30 B.t.u./hr./° F./sq. ft. of particle surface. From this value the drying time for 200 μ droplets of tomato paste was estimated to be 2.6 seconds for the operating conditions described above. Other investigators *(6)* estimate the drying times for 200 μ droplets of pure water to be in the order of 1.5 seconds under similar conditions. For droplets containing solids in solution or suspension, the drying time is considerably longer. This is particularly true when "case hardening" or other complications of drying occur.

It is seen that the time required to dry 200 μ droplets of tomato paste may easily be well over 2 seconds. Droplets of this size or larger will not be dried sufficiently to prevent sticking and loss of product by wall deposition under conditions used in these runs. Indirect substantiation of these considerations is found in the fact that all particles of product discharged from the unit were below 150 μ in diameter.

The problem of wall deposits is still serious for the drying chamber used in these tests. Future research toward solution of this problem should include studies on a drier of larger diameter, investigations of improved means of atomization, and improvement of drying conditions.

Operating equations. The moisture content of spray-dried tomato powder is a complex function of operating variables. For most of the runs made in the present equipment, however, a good correlation existed between powder moisture content, Mp, and the calculated "finish-drying temperature," T_f. T_f (the temperature of the primary hot air stream after it is evaporatively cooled by the spray and before introduction of secondary air) may be calculated by means of the equation:

$$T_f = T_h - \frac{44 M_f F}{H} \qquad (1)$$

Where T_f = finish drying temperature, ° F.
T_h = hot air inlet temperature, ° F.
M_f = moisture in feed, % H_2O
F = feed rate, lbs./min.
H = hot air flow rate, lbs./min.

(Heat losses and air channeling are neglected.)

Product moisture content, M_p, was experimentally found to be a function of T_f:

$$T_f = 383 - 31.3\ M_p \qquad (2)$$

Combining equations (1) and (2) we have

$$M_p = \frac{1.41\ M_f F}{H} - \frac{T_h - 383}{31.3} \qquad (3)$$

Equation (3) expresses the moisture content of tomato powder in terms of the drying variables. It has been useful for selecting the values of operating variables to obtain a product of a desired moisture content. This equation may not be directly applicable to other driers, but the same principles of analysis can be applied. Of course, the atmosphere in the collection zone, time of exposure, differences in feed material, and other factors also affect moisture content of product. For example, moisture content of tomato powder was 0.5 to 0.8% higher when undehumidified air was used in the powder aspirator instead of dehumidified air.

Properties of the product. Moisture level and its effect on sticky point and hygroscopicity of tomato powder have been discussed earlier. Tomato powder that is high in moisture content when produced will immediately cake or lump. As the moisture content is progressively reduced, the tendency to cake upon standing diminishes and finally disappears. The level of

moisture content below which no caking occurs in stored tomato powder is not definite, because factors other than moisture may also contribute toward caking —such as particle size and/or state of agglomeration, raw material used, additives, storage temperature, and perhaps others. For tomato powder produced under conditions of these tests, however, 2% was approximately the moisture level that divided caking and noncaking products.

Sulfite in the feed paste was found to protect the product against scorching during spray drying. Similar results were found in vacuum drying of tomato (*4*). The salt added also appears to suppress scorching somewhat; however, the primary advantage in the use of salt is to decrease caking tendency. Runs were made without salt and sulfite, but product quality was judged lower. It was found that only 25 to 40% of the sulfite added to the feed is retained in the product. When the powder was reconstituted as juice the sulfur dioxide concentration was below 30 p.p.m. and could not be detected by the average taster.

The tomato paste used as a starting material in these tests contained about 170 mg. of ascorbic acid per 100 g. of dry solids. Over 90% of this ascorbic acid was retained in the product.

Bulk densities of spray-dried tomato powders were affected only slightly by the conditions of production:

Feed % total solids	Feed rate lbs./min.	Tp °F.	Bulk density, g./ml.	
			Loose	Packed
22	4	412	0.60	0.82
22	5.8	460	0.58	0.75
11	3.5	412	0.62	0.88
11	5.5	460	0.61	0.80

Obviously, the packing of the powder has far greater effect on bulk density than the conditions of preparation. Bulk densities of spray-dried tomato powders are considerably higher than those of vacuum-dried powder.

In reconstituting the powder to obtain paste (25% solids content), one volume of powder is mixed with two volumes of water. For preparation of small lots, vigorous stirring with a spoon results in a satisfactory product. For preparation of 4-pound batches of paste, a planetary-type, wire-whip mixer was used. Several types of mixers commonly used in food processing plants and large restaurants should be suitable for preparing paste in quantity.

Juice of beverage strength (6.5% solids) and normal consistency can be prepared by mixing one volume of powder with 9 volumes of water for 30 to 60 seconds in a kitchen-type blender. Care should be taken to avoid whipping air into the mixture. If a blender is not available, it is necessary first to make a smooth heavy paste and then dilute slowly, with stirring, to the concentration desired. Failure to use these procedures results in a mixture with a thin, weak consistency, which separates upon standing. Thin, separating samples of improperly reconstituted juice were examined microscopically. Individual spray-dried particles were dispersed fairly well, but had not disintegrated. However, when the sample was exposed to vigorous shearing action as afforded by stirring as a paste, or by mixing in an electric kitchen blender, it was found to be suitably disintegrated and had the appearance of tomato juice. Very few or no particles having the identity of the dried spray droplets remained. The conclusion from these observations is that each spray-dried particle has a tough shell which is not ruptured by mild stirring in cold water.

SUMMARY

An experimental spray drier was modified for drying tomato concentrate. Modifications included provisions for introduction of controlled amounts of ambient air into the lower part of the drying chamber to condition the surfaces of the particles before they enter the primary cyclone collector. An aspirator was provided to transfer the powder from the humid air of the first collector to the warm dehumidified air used in the secondary collection system. This arrangement prevented sticking of powder in the collection zone.

Preparation of the concentrate used as starting material was carefully controlled to preserve most of the natural pectin and to exclude coarse particles which interfere with atomization. A small amount of sodium bisulfite was added to the starting material to stabilize the product against heat damage during drying. Sodium chloride was added to aid in drying and to decrease caking tendency of the product.

Noncaking powder of good quality was produced. Advantages of this new product over vacuum-dried tomato powder include greater packing density and potentially lower production costs. However, since the spray-dried powder is rated lower in flavor and mixes less readily with water, it is less attractive for beverage use than the vacuum-dried product. Pastes made from the spray-dried powder have excellent color and consistency and acceptable flavor; use in dry soup mixes and in products where tomato paste is normally used appears promising.

Optimum production conditions and procedures for minimizing deposition of powder in the main drying chamber must be established, and storage tests on the product must be completed before this development can be fully evaluated.

Acknowledgments

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Some Factors Affecting the Heat Stability And Viscosity of Half-and-Half Homogenized Milk[a]

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One of the defects of half-and-half homogenized milk is "feathering." For many years, this defect, also characteristic of coffee cream (18% fat), has given rise to many consumer complaints. "Feathering" occurs when the cream comes in contact with hot coffee.

Numerous studies have been conducted to ascertain the various factors which produce the feathering of coffee cream *(2, 3, 5, 7, 10, 11, 12, 13, 17)*. Only a limited amount of study has been devoted to problems pertaining to the composition and processing of half-and-half homogenized milk *(4, 8, 9, 14, 15)* and their possible effect on feathering. Because the percentages of fat and solids-not-fat/fat ratio of half-and-half homogenized milk differ materially from those of coffee cream the applicability of knowledge pertaining to coffee cream to the problems encountered with half-and-half homogenized milk seems somewhat questionable.

This study was initiated to ascertain the influence of composition and processing techniques on some of the properties of half-and-half homogenized milk believed to be related to the feathering defect.

EXPERIMENTAL PROCEDURE

Preparation of experimental samples. Fresh, mixed herd, raw milk was obtained from the Michigan State University creamery. This milk was warmed to 90° F. and separated. The resultant skim milk and cream were used to prepare 6 lots of experimental, standardized half-and-half homogenized milk. The first 3 lots contained 10.5% fat with additions of approximately 2 and 5% low-heat, nonfat dry milk to the respective second and third lots. The remaining 3 lots were standardized to approximately 13%, 18% and 23% fat, respectively. In this manner, wide variations in the compositions and SNF/F ratio were achieved. Each lot of samples was pasteurized at 150° F. for 30 min. followed by immediate homogenization at 0, 2,500 and 5,000 p.s.i. (single-stage) and 2,500 + 500 and 5,000 + 500 p.s.i. (two-stage) in a 75 gal./hr., Manton-Gaulin homogenizer. Several half-pint samples of each experimental lot were bottled in glass, cooled in running water to approximately 50° F. in 15 min. and stored at 37° F. until examined.

Experiments were performed in triplicate with milk from a constant source. The data represent typical observations. No attempt was made to observe the relative effects of seasonal variations.

Evaluation procedures. Viscosity values were determined with a Brookfield Synchro-Lectric Viscometer. Determinations were made at the temperature of 3° C. (37.5° F.) following a 30 min. tempering period; results being expressed in centipoises. All samples were aged at 37° F. for at least 6 and not more than 10 hours prior to making viscosity determinations.

Values reflecting the relative heat-stability of the prepared half-and-half milk samples were determined simultaneously. One ml. samples, sealed in round Pyrex glass tubes 15 cm. long, were heat treated in an oil bath at 120° C. (248° F.). These submerged tubes were rotated constantly from their center point at 7 r.p.m. The interval, in minutes, between the time the sample tubes were submersed and the appearance of the first trace of precipitated milk on the side of the tube was recorded as heat-stability.

The "featherability" of half-and-half homogenized milk in hot coffee was determined by adding 50 ml. of hot coffee (195° to 205° F.) to 5 ml. of sample. The coffee was prepared by adding 3 g. of regular-grind coffee to 50 ml. of boiling distilled water containing calcium-ion ($Ca Cl_2$) concentrations ranging from 0 to 400 p.p.m. This "brew" was allowed to boil for one minute, then added to the milk sample.

The stability of the various lots of half-and-half homogenized milk to hydrogen ions in the presence of various concentrations of calcium, magnesium, and citrate ions was estimated as follows: 5 ml. of calcium chloride, magnesium chloride and/or sodium citrate solutions containing a calcium-, magnesium- or citrate-ion concentration ranging from 0 to 500 p.p.m. was mixed in a test tube with 1 ml. of sample. Increments of N/100 HCl were added and mixed until the first indication of fine precipitate was observed. The milliliters of acid constituting the titre was recorded as the "acid-stability" of the sample.

RESULTS AND DISCUSSION

Effect of homogenization on viscosity and heat-stability of half-and-half homogenized milk. The influence of homogenization at 2,500 p.s.i. and 5,000 p.s.i., both single and double stage, on the viscosity and heat-stability of half-and-half homogenized milk of approximately 10% fat and ranging in solids-not-fat concentration from approximately 8.5% to 12.5% is shown in Figures 1 and 2. These data indicate that a small

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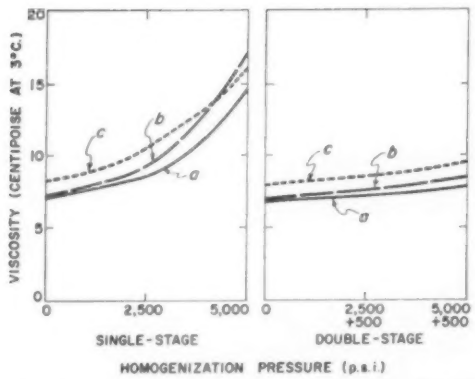

Figure 1. The effect of homogenization on the viscosity of half-and-half homogenized milk. Curve a—10.50% F, 8.73% SNF, SNF/F = 0.825. Curve b — 10.47% F, 10.05% SNF, SNF/F = 0.959. Curve c—10.28% F, 12.38% SNF, SNF/F = 1.204.

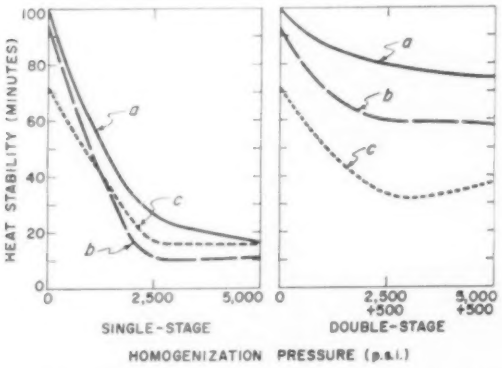

Figure 2. The effect of homogenization on the heat stability of half-and-half homogenized milk. Curve a—10.50% F, 8.73% SNF, SNF/F = 0.825. Curve b — 10.47% F, 10.25 SNF, SNF/F = 0.959. Curve c—10.28% F, 12.38% SNF, SNF/F = 1.204.

increase in viscosity occurred in the milk samples fortified with nonfat solids. A more pronounced increase in viscosity occurred, however, in samples subjected to single-stage homogenization at pressures upward to 5,000 p.s.i. Double-stage homogenization did not contribute to the occurrence of unusually high viscosities in the aged samples. These observations are in agreement with those data reported by Brunner *(1)* and by Trout and Weinstein *(15)* in related studies.

Similarly, the addition of nonfat solids lowered slightly the initial heat-stability of the nonhomogenized half-and-half milk samples. Single-stage homogenization at a pressure of 2,500 p.s.i. reduced the heat-stability of the milk samples to relatively low values. Double-stage homogenization adversely affected the heat-stability of half-and-half. However, the second-stage did exert a slight heat-stabilizing influence on the milk samples. This was especially noticeable in the samples without the added solids. The fat concentration in the 3 samples of half-and-half represented by these data were approximately the same. Therefore, the wide variation between the heat-stability values in the double-stage homogenized samples appears to be the result of the added solids. Doan *(5)* has postulated that the decreased heat-stability of homogenized milk was in part the result of immobilizing a large portion of the milk casein on the greatly increased surface of the homogenized fat. Such a condition could be magnified in a relatively high-fat milk containing added nonfat dry milk. Doan and Minster *(6)* reported that the addition of nonfat milk solids tended to heat-stabilize low-fat cream. The results reported herein agree with the reports of Webb *(16)* and Whittier and Webb *(18)* who emphasize the heat-destabilizing influence of nonfat dry milk.

The effect of single- and double-stage homogenization on the viscosity and heat-stability of samples ranging in fat concentration from 10.47% to 22.74% is shown in Figures 3 and 4. The sharp increase in viscosity and correspondingly prominent decrease in heat-stability of high-fat samples, homogenized under single-stage conditions are apparent. These observations have been reported on numerous occasions *(5, 16, 17)* and presumably are the results of excessive clumping of the

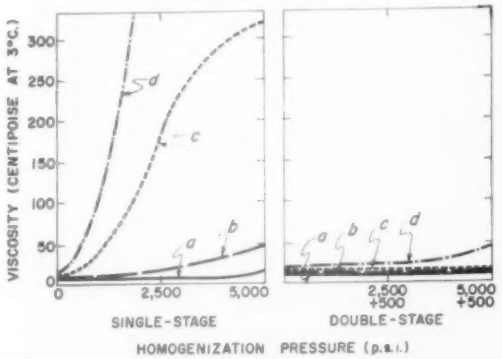

Figure 3. The effect of increasing percentages of fat on the viscosity of half-and-half homogenized milk, homogenized at various pressures. Curve a—Half-and-half; 10.47% F, 10.05% SNF, SNF/F = 0.959. Curve b — Half-and-half; 12.76% F, 7.87% SNF, SNF/F = 0.617. Curve c — Cream; 18.44% F, 7.50% SNF, SNF/F = 0.407. Curve d—Cream; 22.74% F, 7.16% SNF, SNF/F = 0.315.

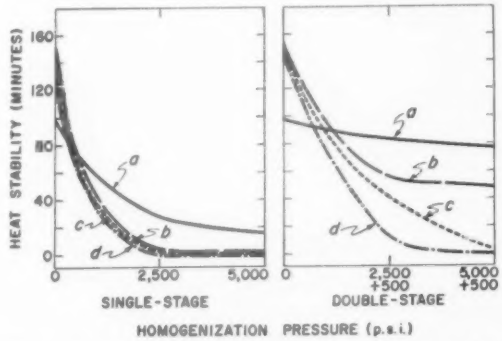

Figure 4. The effect of increasing percentages of fat on the heat stability of half-and-half homogenized milk, homogenized at various pressures. Curve a—Half-and-half; 10.47% F, 10.05% SNF, SNF/F = 0.959. Curve b — Half-and-half; 12.76% F, 7.87% SNF, SNF/F = 0.617. Curve c—Cream; 18.44% F, 7.50% SNF, SNF/F = 0.407. Curve d—Cream; 22.74% F, 7.16% SNF, SNF/F = 0.315.

globular fat. Apparently, very little clumping occurred in the homogenized samples when the SNF/F ratio was greater than 0.62. Doan *(4)* reported that the critical SNF/F ratio conducive to the clumping of fat in light cream homogenized at 100° F. ranged between 0.60 to 0.85.

Double-stage homogenized experimental samples were lower in viscosity and higher in heat-stability than similar samples processed by single-stage homogenization. Generally, this beneficial effect of two-stage homogenization has been attributed to the break-up of fat clumps which serve as a focal point for matrix formations in the development of viscosity and heat flocculations *(5, 10)*.

"Featherability" in hot coffee. None of the samples of half-and-half homogenized milk prepared for this study could be "feathered" by either the addition of hot coffee to the sample or vice versa. These observations re-emphasize the importance of freshness in the raw materials as a means of avoiding the feathering defect in half-and-half homogenized milk. However, when coffee was made with distilled water rather than with common tap water (containing 419 p.p.m. as $CaCO_3$) feathering was sometimes observed, especially in the samples homogenized by single-stage treatment and at higher-than-normal pressures, Table 1.

The addition of increments of calcium to the distilled water used in making the coffee emphasizes further the destabilizing influence of homogenization on the heat-stability of half-and-half homogenized milk. Again, the partial stabilizing influence of the second-stage of double-stage homogenization was demonstrated. One of the interesting observations of this study was the inability of the hard-water coffee to feather the half-and-half samples while relatively low concentrations of calcium (ranging from 0 to 125 p.p.m.) in distilled-water coffee resulted in the destabilization of all the homogenized samples. A possible explanation lies, of

TABLE 1

The influence of composition and homogenization on the feathering of half-and-half in coffee containing various concentrations of calcium-ion.

Calcium-ion concentration in coffee	Occurrence of feathering in half-and-half homogenized milk homogenized at:											
	0 (p.s.i.)			2500 (p.s.i.)			2500 + 500 (p.s.i.)			5000 (p.s.i.)			5000 + 500 (p.s.i.)		
	Series			Series			Series			Series			Series		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
(p.p.m.)															
Hard Water[1]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
0	–	–	–	–	±	–	–	–	–	+	+	+	–	–	–
50	–	–	–	+	±	–	–	–	–	+	+	+	±	–	+
75	–	–	–	+	+	±	±	–	–	+	+	+	+	±	+
100	–	–	–	+	+	+	+	–	+	+	+	+	+	+	+
125	–	–	–	+	+	+	+	±	+	+	+	+	+	+	+
150	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+
200	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+
300	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
400	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Legend:
No feathering = –
Questionable feathering = ±
Definite feathering = +
Series No. 1 = 10.50% F., 8.73% S.N.F.
Series No. 2 = 10.47% F., 10.05% S.N.F.
Series No. 3 = 10.28% F., 12.30% S.N.F.

[1] Tap water testing 419 p.p.m. as calcium carbonate

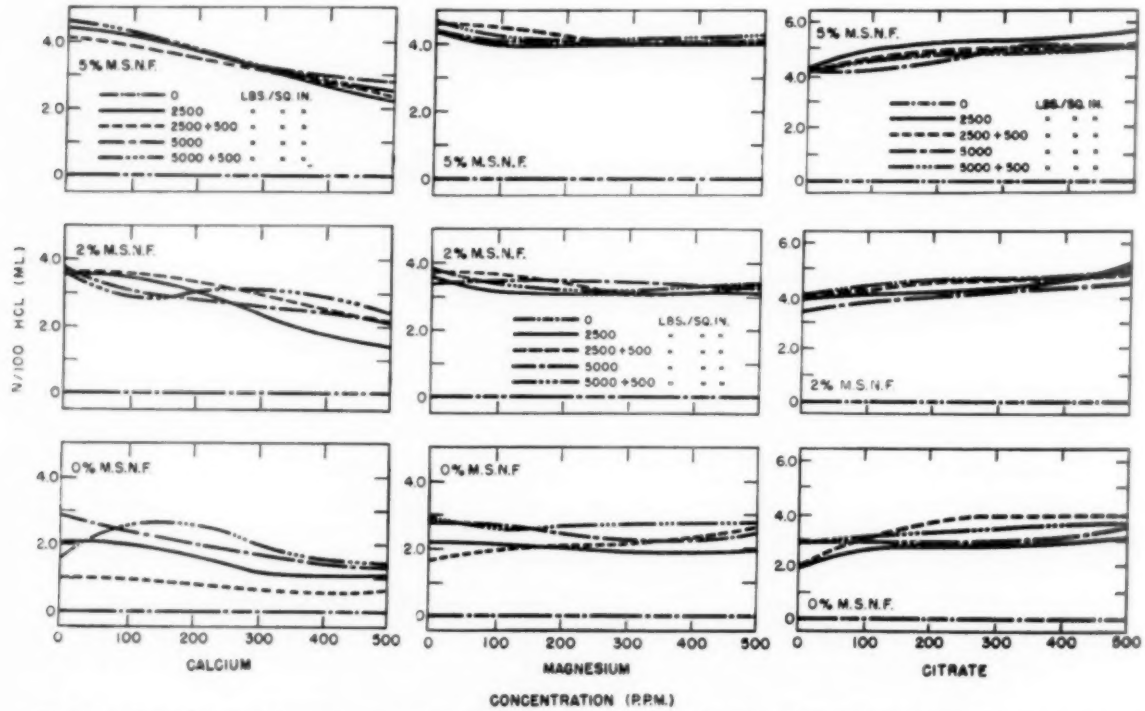

Figure 5. The influence of increasing amounts of calcium-, magnesium- and/or citrate-ions on the acid-stability of samples of half-and-half homogenized milk and half-and-half homogenized milk plus 2% and 5% added M.S.N.F.

course, in the more favorable balance of cations and stabilizing anions in the natural water system.

The acid-stability of half-and-half homogenized milk. The data shown in Figure 5 demonstrate the stabilizing effect of added nonfat dry milk to the destabilizing influence hydrogen ion added to samples of half-and-half. Further, the increased destabilizing or stabilizing influence of added calcium, magnesium and/or citrate is indicated. Added increments of calcium to the test mixture resulted in a progressively more sensitive acid precipitation. Unlike the effect of calcium, the addition of magnesium had little influence on the acid sensitivity of the half-and-half samples. The addition of citrate to the samples had the effect of stabilizing the milk to the precipitation by acid.

SUMMARY

Processing and compositional factors affecting the viscosity and heat stability of half-and-half homogenized milk were studied.

The viscosity of half-and-half homogenized milk was increased by single-stage homogenization, especially at higher-than-normal pressures. Double-stage homogenization produced less increase in viscosity in similar samples. Effects of homogenization became more pronounced as the fat content of the sample was increased upward to that of light cream.

Generally, the heat-stability of the homogenized samples followed an inverse relationship to that of viscosity. Other factors being approximately equal, the addition of nonfat dry milk resulted in a product of lower heat stability.

None of the fresh experimental samples could be induced to "feather" in coffee made with hard, "tap" water.

The inclusion of various increments of calcium in distilled-water coffee demonstrated that homogenization, especially single-stage processing, was conducive to the appearance of the "feathering" defect.

The addition of nonfat dry milk to the samples served as a "buffering" agent against the acid-precipitation of half-and-half homogenized milk.

Generally, increasing increments of added calcium resulted in a lowering of the acid-stability of the sample; whereas, the addition of citrate resulted in an increase in the acid-stability. Magnesium had apparently little effect on the acid-stability.

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Studies Related to the Manufacture Of Filled Cheese

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Methods for the preparation of filled milks suitable for making filled cheese of the cheddar type are described. The use of filled milks in the manufacture of such cheese is shown to be feasible.

The continuous search for the development of new foods that will meet the consumer's approval is apparent to anyone in the food field. The present high price for milk fat in relation to animal fats and vegetable fats and oils, combined with an intensive drive to find more and greater outlets for these latter fats and oils in the food field, has resulted in a renewed effort to develop products in which the milk fat is replaced partially or wholly by other fats.

Although the manufacture of filled cheese is practiced in some parts of this country and elsewhere, literature dealing with its manufacture is rather meager. The present study was undertaken to develop methods for the preparation of filled milks suitable for making filled cheese of the cheddar type and to use such milks in the manufacture of filled cheese.

REVIEW OF LITERATURE

Nichols *(6)* has published a method suitable for manufacture of nonfat leaking cheddar cheese from reconstituted milk. A method similarly satisfactory in dispersing fat in natural whole milk, which simultaneously reduces fat leakage in cheese has been developed since by the author *(8)*.

Feuge *(2)* has shown that interfacial tension between water and oils, such as cottonseed and soybean oil can be reduced by added monoglycerides. A 1% concentration of monoglycerides in the oil phase lowered the interfacial tension by 50% and a 6% concentration by 100%.

Norman *(7)* has reported that dried buttermilk improved the palatability and flavor of reconstituted homogenized whole milk. Reisfeld and Harper *(9)* have developed a low-fat soft-ripened cheese containing added buttermilk. These workers found that whereas added phospholipids produced the same long body in cheese as did added sweet cream buttermilk, the latter cheese possessed superior spreading qualities.

Methods suitable for preparing cheese samples for bacteriological examination are described by Hammer *(4)* whereas Alford and Frazier *(1)* have developed a method for obtaining counts of lactic and nonlactic organisms in cheese.

EXPERIMENTAL

Filled cheese of the cheddar type was made by a conventional method *(10)*. In trials involving the use of natural skim milk sufficient milk from the College herd was set aside for each series to give four 200-lb. lots after processing, plus the necessary skim milk to make the starter. A 200-lb. portion of the raw whole milk was withheld in series where a natural control cheese seemed desirable.

All milk to be skimmed was forewarmed to 40° C. and separated in a mechanical separator. The skim milk was transferred to a holder type pasteurizing vat and heated to 55° C. at which time vegetable fat of the same temperature was added in amounts equal to that of the milk fat removed by skimming. In the early trials dealing with homogenization pressure as variable (Table 1 A.) the filled milk was then pasteurized at 61.7° C. for 30 minutes, cooled in the vat to 50° C. and three consecutive portions of 200 lb. each withdrawn and homogenized in a Manton-Gaulin homogenizer at 500, 1000 and 2000 p.s.i. respectively. Since this method presented difficulties in obtaining consecutive lots of filled milk having the same percent fat a modification in procedure was adopted. Thus after adding the calculated amount of liquid vegetable fat to each individual lot of preheated skim milk, both at 55° C., the mixture was homogenized immediately at 500 p.s.i., returned to the vat, pasteurized at 61.7° C. for 30 minutes, and rehomogenized at 500 p.s.i. on the way to the surface cooler. Good results were obtained by this method at all times. (Caution: in order to prevent hydrolytic rancidity the above first homogenization temperature of 55° C. should be rigidly adhered to.)

The natural control milk received a pasteurization treatment similar to that of the filled milk but was not homogenized.

In trials involving the use of reconstituted skim milk, Extra Spray Low Heat N.D.M.S. were added to tap water of 25-32° C. at the rate of 9 lb. to 91 lb. and dissolved under agitation. The resulting reconstituted skim milk was forewarmed to 55° C. and melted vegetable fat at 55° C. added in amounts to result in a 4% fat filled milk. A 4% fat reconstituted filled milk was selected to approximate the College herd milk. This seemed desirable since some series were to include natural milk control cheese. Further treatment of the reconstituted filled milk was according to the modified method described above.

All filled cheeses, unless shown otherwise, were made from filled milk or reconstituted filled milk containing hydrogenated cottonseed oil with a Wiley melting point of 35.8° C.

When used, monostearine and low heat sweet cream buttermilk powder were first incorporated into the melted vegetable fat prior to its addition to the preheated skim milk base.

All cheese was made in four identical 50-gallon stainless steel Damrow cheese vats. Cheese color was added to the milk to give all cheese the same intensity of color. The same make

TABLE 1

The influence of type and treatment of milk upon fat loss in whey, oiling off and pH of cheese

Type of cheese	Homo. pressure in p.s.i.	Percent fat loss in whey	Percent oiling off in cheese	pH at age of 1 month
A. Filled milk cheese				
Filled	500	0.06	18	5.4
Filled	500	0.08	16	5.4
Filled	1000	0.04	12	5.4
Filled	1000	0.08	16	5.5
Natural	0	0.14	...	5.3
Natural	0	0.34	42	5.4
B. Reconstituted filled milk cheese				
Filled	500	0.06	15	5.5
Filled	1000	0.11	15	5.3
Filled	1000	0.10	11	5.6
Filled	2000	0.08	2	5.5
Natural	0	0.27	50	5.3
Natural	0	0.34	31	5.5

schedule was rigidly adhered to in all instances. The curd from each lot or vat was made into 4 cheeses of the American favorite style. The cheese was kept in the press overnight, removed from the hoops, stamped for identification and paraffined after the rind was sufficiently dry. The paraffined cheese was cured on shelves at 10 to 13° C.

Fat tests on milk, whey and cheese were made by the modified butyl alcohol Babcock method *(3)*. Moisture in cheese was determined in duplicate on 5-g. samples of ground cheese dried at 105° C. for 24 hours. Fat leakage, expressed as percent oiling off, was determined on 20-g. samples of ground cheese suspended in 80 ml. of distilled water having a temperature of below 33° C. and containing one part of formaldehyde to 500 parts of water. Samples prepared in the above manner were held for 24 hours at 37° C., centrifuged for 15 minutes at 1000 r.p.m. in a Cenco high speed centrifuge and refrigerated overnight at 3-4° C. to allow the free fat to solidify. The solidified fat was removed and weighed and the percent fat leakage calculated, based on the percent fat in the cheese. The pH values were determined with a Beckman potentiometer on samples prepared by dispersing 2 g. of ground cheese in 18 ml. of boiled cooled distilled water.

Photographic illustrations of fat leakage were prepared from a trier plug disc of cheese cut 3 mm. high. The cheese disc was placed in the center of a dry filter paper previously saturated with Sudan III, kept in a petri plate. The petri plate was covered and the cheese exposed for 150 minutes to 37° C., after which time the plate and its contents were cooled in a refrigerator for 15 minutes and the pictures taken immediately.

All cheeses were judged at the age of 3 and 6 months as outlined by Nelson and Trout *(5)*. The identity of the samples was withheld from the judge in all instances.

Since the score card used was designed for natural cheese and did not list certain defects found in filled cheese it was necessary to improvise evaluations for the latter defects and to designate appropriate scores for them. The term "foreign" flavor was selected to denote a flavor uncommon to natural cheese and its severity was portrayed in the score given, depending on the intensity observed.

Bacteriological examinations of cheese were made according to methods described elsewhere *(1, 4)*.

RESULTS

Data shown in Table 1 were obtained from two series each of filled milk cheese and reconstituted filled milk cheese with natural cheese serving as control. All fat losses in whey from the filled cheeses were similar and significantly lower than those of the natural control cheese. The percent oiling off in both types of filled cheese was similar for similar homogenization treatment of milk. However, increases in homogenization pressure of milk resulted in decreases in oiling off in cheese. All filled cheeses had oiling off values much lower than those of natural control cheese made from nonhomogenized milk. No significant differences were observed among the various cheeses with respect to pH at one month of age.

Numerical flavor scores of 3 and 6 months' old filled cheese ranged from a low of 35 to a high of 37, and for natural cheese from 38 to 40. The most common flavor criticisms for filled cheese were *foreign* and *flat*. No significant difference in flavor was observed between filled cheeses made from filled milk or reconstituted filled milk when 3 months old. However, at 6 months the filled milk cheese somewhat excelled the reconstituted filled milk cheese.

Although the body and texture scores of both the filled cheeses and the natural cheese ranged between 26 and 29 there was some difference in the kinds of criticisms. Whereas most cheeses were slightly open in texture only filled cheeses were criticized for being curdy and crumbly, which defects decreased with aging. Since curdiness disappears with breakdown of protein it seemed that ripening in filled cheese progressed at a slower rate than in natural cheese. The data in Table 2 tends to substantiate this fact since the number of lactic organisms found in reconstituted filled milk cheese

TABLE 2

Populations of lactic and nonlactic organisms in six-month-old cheese made from natural, filled or reconstituted filled milk

Agar growth medium	Incubation		Colony count per gram (in millions) in			
	Temp. in ° C.	Time in days	Natural cheese (control)		Filled cheese (1000 p.s.i.)	
			Cheese series 1	2	Cheese series 1	2
A. Filled milk cheese						
Tomato juice (lactic)	35	2	1.1	14.6	1.8	10.0
Tryptone (nonlactic)	30	5	9.0	14.0	15.0	14.8
B. Reconstituted filled milk cheese						
Tomato juice (lactic)	35	2	12.5	9.5	0.3	0.06
Tryptone (nonlactic)	30	5	12.4	25.6	12.4	2.0

was significantly lower than in natural cheese of the same series at the age of six months. Counts for lactic organisms were similar, however, between natural and filled milk cheese as shown in Table 2A.

All filled cheeses used for bacteriological examinations were made from filled or reconstituted filled milk homogenized at 1000 p.s.i. The above cheeses were somewhat superior in body and texture to other filled cheeses of the same series when 6 months old.

Figures 1 and 2 show photographic illustrations of fat leakage in samples of various cheeses made from natural, filled and reconstituted filled milk. Fat leakage

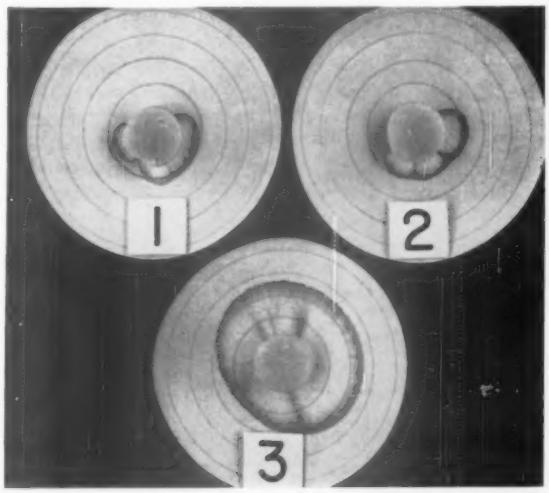

Figure 1. The influence of homogenization of milk upon fat leakage in filled cheese made from filled milk homogenized at (1) 1000 and (2) 500 p.s.i., as compared with natural cheese (3) made from nonhomogenized milk.

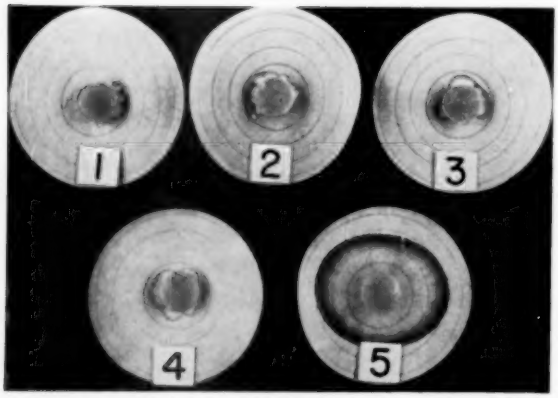

Figure 2. The influence of homogenization of reconstituted filled milk upon fat leakage in filled cheese when using homogenization pressures of 500 (1, 4), 1000 (2, 3) as compared with natural cheese (5) homogenized at 0 p.s.i.

in all filled cheeses was similar and less pronounced than in the natural control cheese made from nonhomogenized milk.

Data on trials involving the use of four different vegetable fats in filled cheese are shown in Table 3. Whereas, the percent fat loss in whey was low and similar in all lots of filled cheese, the percent oiling off declined with higher melting point fats in the reconstituted filled milk cheese but not in the filled milk cheese. No definite trend was observed in the pH values of the various lots of filled cheese.

No significant differences in flavor were observed in the 3 and 6 months old filled cheeses, the scores ranging from 36 to 37 only. Most common criticisms were *foreign, flat* and in some instances *slightly bitter*, especially in the 3 months old cheese. Ripening reduced bitterness in all instances present. Filled cheese containing natural coconut fat showed the lowest incidence of bitterness.

Although the types of body and texture defects were similar in nature for both filled and reconstituted filled milk cheeses having the same type of fat, the defects were less pronounced in filled milk cheese. Filled milk cheese scored from 27.5 to 29 whereas reconstituted filled milk cheese scored from 27 to 28.5. Listed in order of decreasing frequency the criticisms for filled milk cheese were *weak, short*, and *curdy*. In the case of reconstituted filled milk cheese the order was *short, curdy*, and *weak*. Criticism of curdiness was more frequent in filled cheeses containing the higher melting point fats. These cheeses were also more short in body. Filled cheeses containing natural coconut fat, while not curdy in body, were criticized for being slightly greasy.

The addition of 0.5% monostearine on the fat basis (0.5 lb./100 lb. fat) to filled or reconstituted filled milk made into cheese had no apparent effect upon the percent fat loss in whey, percent oiling off and and pH of one month old cheese as shown in Table 4. Similarly, no detectible differences in flavor, body and texture were observed among the various cheeses.

The addition of 14% sweet cream buttermilk powder on the fat basis (14 lb./100 lb. fat) to reconstituted filled milk on the other hand decreased slightly the percent oiling off in one month old cheese. The addition of buttermilk powder resulted in improvement of flavor in the ripened 6 months old cheese over that of the control (37.25 vs. 36.25) as well as in body and texture (28.5 vs. 27.25).

Results of two duplicate series in which natural and filled milk were blended in given proportions and made into cheese are shown in Table 5. The percent fat loss in whey in all cheeses of the same series were low and similar, as were the values of percent oiling off in cheese. Increasing the proportion of filled milk resulted in somewhat higher pH values of the one month old cheeses in both series. A possible explanation for this trend may be that starter organisms produced acid in filled milk at a slower rate as was observed during the daily transfer of cultures in different milks.

The addition of increasing portions of filled milk to natural milk resulted in decreases in flavor scores of

TABLE 3

The influence of type and melting point of fat upon fat loss in whey, oiling off and pH of cheese

Type of fat	Wiley melting point °C.	Percent fat loss in whey	Percent oiling off in cheese	pH at age of 1 month
A. Filled milk cheese				
Natural coconut fat	29.0	0.04	23	5.2
Hydrogenated cottonseed oil	35.8	0.04	32	5.2
Hydrog. soybean oil (A)	36.8	0.03	34	5.1
Hydrog. soybean oil (B)	41.0	0.04	21	5.1
B. Reconstituted filled milk cheese				
Natural coconut fat	29.0	0.05	35	5.6
Hydrogenated cottonseed oil	35.8	0.05	30	5.4
Hydrog. soybean oil (A)	36.8	0.06	26	5.5
Hydrog. soybean oil (B)	41.0	0.03	0	5.8

TABLE 4

The influence of added emulsifier upon fat loss in whey, oiling off and pH of cheese

Emulsifier used		Percent fat loss in whey	Percent oiling off in cheese	pH at age of 1 month
Type	Percent on fat basis			
A. Filled milk cheese				
Monostearine	0	0.08	26.0	5.5
Monostearine	0	0.06	23.0	5.6
Monostearine	0.5	0.08	29.5	5.5
Monostearine	0.5	0.08	26.0	5.5
B. Reconstituted filled milk cheese				
Monostearine	0	0.05	28.0	5.3
Monostearine	0	0.09	30.0	5.3
Monostearine	0.5	0.09	40.0	5.3
Monostearine	0.5	0.05	28.0	5.3
Buttermilk powder	0	0.10	30.0	5.6
Buttermilk powder	0	0.10	30.0	5.6
Buttermilk powder	14.0	0.10	28.0	5.5
Buttermilk powder	14.0	0.10	21.0	5.5

TABLE 5

The influence of various blends of natural and filled milk upon fat loss in whey, oiling off and pH of cheese

Percent blend		Percent fat loss in whey		Percent oiling off in cheese		pH at age of 1 month	
Natural	Filled	Trial number 1	2	Trial number 1	2	Trial number 1	2
100.0	0	0.07	0.12	26	35	5.3	5.3
66.6	33.4	0.06	0.11	23	32	5.3	5.4
33.4	66.6	0.06	0.08	23	40	5.3	5.5
0	100.0	0.06	0.06	28	26	5.4	5.5

the ripened cheese; namely, from 40 to 36. The presence of 33.4% filled milk resulted in detectible foreign flavor in cheese, whereas 66.6% produced a definite foreign flavor. Differences in body and texture of the four lots of cheese in a given series were less pronounced than was the flavor; the differences in score ranging from 29 to 28 in the 6 months old cheese, with the higher scores in favor of the natural cheese. Curdiness present in 100% filled milk cheese was absent in the other lots within the same series.

DISCUSSION

The manufacture of filled cheese from filled or reconstituted filled milk was found to be feasible, even though flavor, and body and texture characteristics differed somewhat from those of natural milk cheese. Homogenization pressures of 1000 p.s.i. or less were found superior to higher pressures in preserving the curd making properties of filled milks. At the same time the above pressures were found to be sufficiently high to properly incorporate the foreign fat into the natural or reconstituted skim milk. Filled milk made into cheese produced a body and texture more similar to that of natural cheese than was obtained with reconstituted filled milk.

The slower rate of ripening in the filled cheeses, especially in those made from reconstituted filled milk, as compared with the natural cheese of the same series must be ascribed either to difference in numbers and types of organisms in the milks prior to cheese making, or to the slower growth of lactic organisms in the filled cheese, or both.

Although the use of monostearine as added emulsifier in filled cheese did not prove advantageous at the level tried, the addition of sweet cream buttermilk powder offers possibilities for improving the flavor as well as the body and texture of filled cheese.

SUMMARY

A satisfactory filled milk for making filled cheese of the cheddar type was obtained by homogenizing at 500 p.s.i. a mixture of natural skim milk or reconstituted skim milk and vegetable fat at 55° C. before and after pasteurization. The above treatment sufficiently incorporated the fat to cause little loss in the whey and retarded oiling off in cheese, while still preserving satisfactory curd making properties in the filled milk.

A comparison of four vegetable fats differing in melting point and/or in origin did not show a clear-cut superiority of any one of the fats, when used in the manufacture of filled cheese.

No advantages in flavor, body, and texture were observed in ripened filled cheese made with added monostearine. However, the addition of sweet cream buttermilk powder to reconstituted filled milk resulted in improvements of flavor as well as body and texture in the ripened cheese.

Increasing the proportion of filled milk added to natural milk progressively decreased the flavor score. A similar but less pronounced trend was observed in the body and texture of the ripened cheese.

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Meat Tenderization. I. Two Mechanical Devices for Measuring Texture[a]

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(Manuscript received October 14, 1955)

Two new methods for measuring meat texture based on the use of a motorized Christel Texturemeter and a household food grinder are described. The accuracy of these methods and mechanical devices was evaluated using waxes as the homogeneous test material. A coefficient of variation of 2% shows that these methods are more accurate than the popular Warner-Bratzler Shear. Examples of the application of these two mechanical devices to measurement of meat texture are given.

Foremost of the factors considered in meat acceptability is tenderness, a quality which has proved thus far to be very difficult to evaluate. Consequently, various methods—organoleptic, mechanical, and histological—have been devised and used with varying degrees of success to measure meat texture.

In the present investigation, mechanical methods of measuring meat texture were studied to find mechanical devices and methods capable of distinguishing between relatively small differences in texture in a reproducible manner. Of all the devices and methods in present-day use, none appeared to fulfill these requirements satisfactorily. References to and short descriptions of these methods can be found in Bate-Smith's excellent review *(2)*. The Warner-Bratzler shear has been used most extensively—in fact, almost exclusively compared to other mechanical methods of measuring meat texture. The reliability of measurements obtained with this device was recently reported by Hurwicz and Tischer *(3)* who felt that the experimental error inherent in the apparatus was sufficient to warrant a redesigning of the instrument.

In this study, other devices and principles are presented which possess some desirable attributes and merit consideration in the search for better methods of measuring texture. The scope of this investigation includes the calibration of a shear apparatus and a food grinder and their application to measurement of meat texture. The calibration of the shear apparatus, a motorized Christel Texturemeter, was determined by analyzing the precision of measurements obtained by shearing samples of beeswax at five different temperatures. The two criteria selected from these measurements as measures of texture were the total work and the maximum shear force. Beeswax was selected because of its homogeneity, resistance to fracture, and variable resistance to shear as a function of temperature. In its application to meat, the motorized Christel Texturemeter was used to determine the correlation of measurements of total work and maximum shear force with the thickness of meat samples. The food grinder was calibrated with parowax. In this case, the criterion of texture was the energy expended in grinding a given weight of parowax. Parowax was used because of its homogeneity and good grinding properties. In the application of the Hamilton-Beach food grinder to measuring textural differences in meat, pieces of freeze-dried *biceps femoris* muscle of beef were rehydrated in enzyme solutions, cooked, and ground. By measuring power consumption during grinding, data were obtained on the relative tenderization produced.

METHODS

Motorized Christel Texturemeter. The modification of the Christel Texturemeter simply involved the attachment of an electric motor and reduction gears to give a 0.75 r.p.m. drive to the shaft of the texturemeter. This produced both a reduction of shear rate to 0.32 mm. per sec. and a non-fluctuating rate of shear.

Total work and maximum shear force were obtained in the following manner. The cylindrical sample was placed in the sample holder and the motor started. As soon as the shearing prongs touched the sample, manual recording of the texturemeter pressure gauge readings was begun. A bell mechanically activated by the drive mechanism signaled for readings at intervals of approximately 2 sec. When the shearing prongs had passed through the sample, the motorized drive was reversed and the shearing prongs were elevated for the next test. Work diagrams were obtained by plotting the recorded data in pounds of force as a function of the distance measurements, which were easily computed from the time intervals and the known speed of the motorized drive.

In all of the following measurements, the base line for the integration of work diagrams began at 30 pounds force. The other linear boundary, denoting the end of shear, was calculated from the thickness of the sample and the speed of the drive. Altogether, these boundaries determined the dimensions of the work diagrams. The area under the force-distance diagram was obtained as an average of 3 planimeter readings. An example of a work diagram obtained with beef *semitendinosus* is given in Figure 1. The maximum shear reading was obtained by recording the force reading at the crest of the force-distance diagram.

Shear tests of beeswax were made in quadruplicate at 5 different temperatures (80°, 86°, 90°, 95° and 110° C.). The beeswax samples were cut into cylinders 4.80 cm. in diameter and 1.20 cm. thick. These samples were brought to the required temperature and tested immediately.

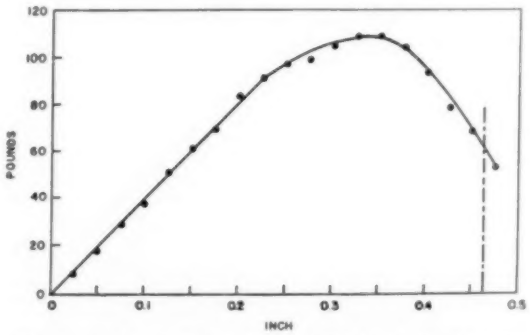

Figure 1. A typical work diagram obtained with the motorized Christel Texturemeter.

[a] Supported in part by a grant from the Adolph's Foundation.

In applying this method to meat, the shear force as a function of sample thickness was investigated. Sections of two *semitendinosus* muscles of beef were pressure cooked for 45 min. at 10 p.s.i. The meat was cooled to room temperature and then sliced with the grain of the meat to predetermined thickness. Cylindrical samples 4.8 cm. in diameter were cut with a cork borer and the thickness of each sample was remeasured on 4 sides with a vernier caliper. The reported thickness measurement is an average of the 4 readings. The meat samples were then sheared in the motorized Christel Texturemeter and the measurements of total work and maximum shear force obtained as described previously.

Hamilton-Beach food grinder. In considering other techniques to determine texture, it appeared feasible to determine meat texture by its resistance to grinding. Chewing and grinding are similar in that both involve integrated operations of conveying, squeezing, tearing, and cutting. This analogy can be carried further by feeding into the grinder bite-size pieces of meat and by selecting a grinder plate that produces chewed-size pieces. Theoretically, by this method, increasing toughness of meat texture would produce a corresponding, proportionate increase in current consumption of the grinder. The area described by a plot of power consumption in watts as a function of item would represent the total energy expended in grinding the sample. Measurements of texture can then be described as the energy required to grind a given amount of sample. Similar techniques have long been used to measure the relative plasticity of doughs (*11*).

A Hamilton-Beach food mixer (model *G*) was equipped with a power unit (model *2*), a grinder (model *4*), and a grinder plate containing 36 holes 5 mm. in diameter. The motor was wired in series with an A.C. ammeter. Parowax was used to measure the precision of this instrument. Four 150-g. samples of parowax cubes weighing approximately 2 g. each were manually fed into the grinder at a uniform rate. The ampere readings were recorded at 5-sec. intervals. A plot was made of these ampere readings as a function of time, and the area under the resulting curve was obtained with a planimeter and converted into energy per unit weight of sample.

The following procedure was used to test the applicability of this method to measurements of meat texture. Freeze-dried samples of *biceps femoris* of beef were rehydrated in the following solutions: 1% papain, 0.1% papain, 1% commercial meat tenderizer containing papain, and water which was used as the control. Pieces of *biceps femoris* were cut into samples approximately 1 x 1 x ¾ inches. Samples of approximately 80 g. dry weight were selected by random sampling. Rehydration was carried out under vacuum and was complete after 30 minutes as ascertained by inspection of cross-sections of the rehydrated samples. The rehydrated samples were pressure cooked 15 minutes at 10 pounds pressure, and their texture was evaluated in the grinder. Typical work diagrams obtained by grinding 150-170 g. beef are shown in Figure 2.

RESULTS AND DISCUSSION

The results of calibrating the motorized Christel Texturemeter with beeswax are given in Table 1. The relative merits of the two criteria for tenderness being tested can be evaluated from this table, which gives the variation, mean values, and coefficients of variations associated with each measurement. Application of Bartlett's test of homogeneity to both criteria indicated homogeneity of variances at the 2% level and hence justified the pooling of data. Measurements of maximum shear forces showed a smaller coefficient of variation than total work for the pooled data; however, the difference between the two values was small. An analysis of variance (Table 2) of the two criteria indicated that maximum shear force and total work both have a high ability to distinguish between treatments. In this analysis of results, the total work was found to be the better criterion of texture because of its higher "F" value. A statistical analysis of the results reveals little difference between the maximum shear force and the total work for measuring the tenderness of beeswax with the motorized Christel Texturemeter. For convenience, the maximum shear force, requiring a single reading, would be the more desirable method.

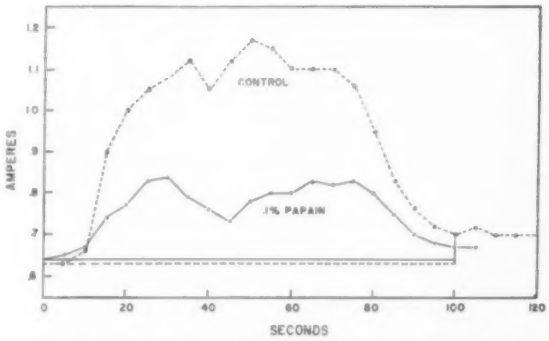

Figure 2. Typical work diagrams obtained with the food grinder.

TABLE 1

Variations and mean values of two criteria of tenderness for beeswax

Wax temp. °C.	Max. shear force, lbs.				Total work			
	Average	σ^2	σ	C.V., %	Average	$\sigma^2 \times 10^4$	$\sigma \times 10^2$	C.V., %
80	236.75	1.188	1.09	0.460	6.541	32.18	5.67	0.867
86	195.25	10.688	3.24	1.659	5.168	271.57	16.48	3.189
90	144.25	3.688	1.92	1.331	3.521	22.29	4.72	1.341
95	87.25	8.688	2.95	3.381	1.730	29.26	5.41	3.127
110	59.00	0.500	0.71	1.203	0.884	10.36	3.22	3.815
Pooled	722.50	24.752	9.91	1.372	17.844	365.66	35.50	1.990

TABLE 2

Partial analysis of variance for two criteria of tenderness

Source	Max. shear force				Total work			
	Sum of squares	df	M.S.	"F"	Sum of squares	df	M.S.	"F"
Total	98,273	19			88.060	19		
Among means	87,034	4	21,759	29.05[1]	87.914	4	21.979	22,660[1]
Within samples	11,239	15	749		0.146	15	0.0097	

[1] Significant at 1% probability level.

The total work and the maximum shear force as a function of meat-sample thickness were determined (Figures 3 and 4). These data were obtained by test-shearing numerous samples from two *semitendinosus* muscles from different beef animals. The relationship between work and sample thickness approximated an exponential curve, whereas the relationship between maximum shear force and sample thickness approximated a logarithmic curve. However, the proper application of logarithms to the data did not reduce these relationships to the desired linear function.

The results of the calibration of the Hamilton-Beach food grinder with parowax are given in Table 3. The

TABLE 3

Precision of measurements obtained with the Hamilton-Beach grinder

	Parowax samples			
	No. 1	No. 2	No. 3	No. 4
Amp. x Sec.	40.45	38.84	40.87	39.23
Volts	120	120	120	120
Energy (joules)	4854	4661	4904	4708
Wt. of sample (g.)	150	150	150	150
E/g (joules/g.)	32.36	31.07	32.69	31.39

mean for the calculated value, E/g, was found to be 31.88 joules per gram. The standard deviation was 0.67, thus giving a coefficient of variation of 2.11%.

The effect of rehydrating freeze-dried *biceps femoris* muscle of beef with various amounts of papain on the texture of the cooked beef was examined. Results of this application of the Hamilton-Beach food grinder

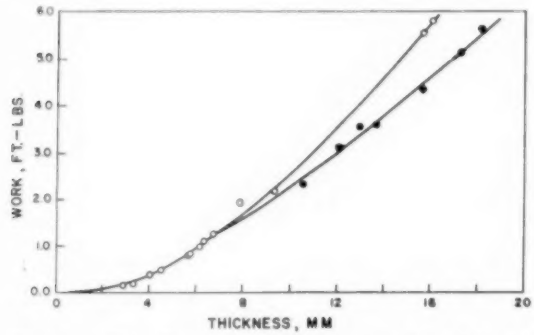

Figure 3. The effect of meat thickness on the total work measured with the motorized Christel Texturemeter.

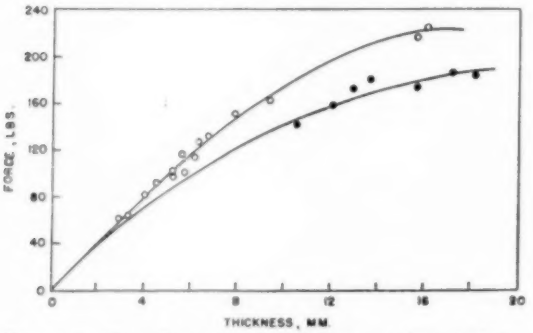

Figure 4. The effect of meat thickness on the maximum shear force measured with the motorized Christel Texturemeter.

to measurements of meat texture are given in Table 4. As expected, the energy expended in grinding a given weight of tenderized beef decreased inversely to the papain content of the rehydration solution.

Fifteen beef samples of varying thickness were measured for maximum shear force with the Kramer shear press, which was found to be less precise for this purpose than the two mechanical devices reported on here.

From a comparison of coefficient of variation values, both the motorized Christel Texturemeter and the Hamilton-Beach food grinder seem to give more precise measurements than the Warner-Bratzler shear device. The coefficient of variation for the Hamilton-Beach grinder was 2.11%. The pooled coefficient of variation for the total work criterion with the Christel Texturemeter was 1.99%, whereas the same value for the maximum shear force criterion was 1.37%. In comparison, Hurwicz and Tischer, in a report on the Warner-Bratzler Shear, obtained pooled coefficients of variation of 4.79, 7.41, and 9.00% for slope of the shear force vs. time curves, maximum shear force, and total time for

TABLE 4

Textural differences of samples of rehydrated, freeze-dried beef as determined by the Hamilton-Beach food grinder

	Samples			
	1% papain	0.1% papain	1% commercial meat tenderizer	Control
Amp. x Sec.	3.06	6.16	14.16	16.71
Volts	120	120	120	120
Energy (joules)	367	739	1699	2005
Wt. of Cooked Beef Sample (g.)	154	173	157	152
E/g (joules/g.)	2.38	4.27	10.82	13.19

failure; they used four replicate samples of beeswax at four temperatures.

With the Christel Texturemeter, both the total work and the maximum shear force criteria were found to be equally precise in the tests with beeswax. However, with meat on which the effect of sample thickness was determined, the total work criterion appears to be slightly better. The Hamilton-Beach food grinder and another similar household food grinder tested were found to be suitable for measuring meat texture. This method presents an advantage in that definite-sized meat samples are not required and no precaution need be taken to line the grain of the meat perpendicular to the shearing head as in the Warner-Bratzler device and the motorized Christel Texturemeter. One disadvantage is the relatively large sample size required, the minimum being about 100 g. The results of this investigation suggest the general applicability to meat texture measurements of any household food grinder in which the power consumption during grinding is large compared to that during idling.

Acknowledgments

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Factors Affecting the Rate of Chicken Meat Dehydration Under Vacuum[a]

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Serving-size pieces of chicken muscle were dehydrated in a vacuum plate drier. Factors studied included drier plate temperature, pressure, initial product temperature and moisture, sample thickness, precooking, and type of muscle. Final product quality was evaluated by means of organoleptic tests and rehydration ratios. Freeze drying was employed for comparison. Vacuum dehydration required one-fourth the drying time without apparent impairment of the initial product quality.

Atmospheric dehydration, which makes use of hot, dry air, has been the method commonly used for dehydrating solid foods. This method, however, does not yield products of the desired high quality in the case of some heat-sensitive foods such as chicken meat. Vacuum dehydration appears to be the better method, from the quality standpoint, for this type of product. It allows use of moderately low to freezing temperatures during the process and offers the following further advantages: (a) few chemical changes such as oxidation occur, (b) micro-biological and enzymatic changes are slight, (c) case hardening can be eliminated, (d) the original shape of the product can be retained, and (e) practically complete rehydration can be attained.

However, in vacuum dehydration high equipment and operating costs are involved. Since food products usually have a low unit value, these costs represent a serious economic obstacle to the application of vacuum dehydration. The unit production cost may be greatly reduced, of course, by an increase in the through-put rate for a given vacuum dehydrator.

The purpose of this study was to develop information on some of the factors affecting the rate of drying under vacuum. Chicken meat, in serving-size pieces, was the product chosen for study.

Previous work. Doty *et al. (2)* reviewed the status of dehydrated meat research in 1953. They concluded, regardless of the dehydration methods used, that the best results were obtained by cooking, grinding, and dehydrating the product as rapidly as possible at temperatures below 70° C.

Basic research on the structural and chemical changes occurring during the dehydration of meats has been reported by several authors *(1, 2, 7)* in recent years.

The dehydration of unground meat in a vacuum tray drier has been studied by Dunker *et al. (3)*. Their results indicated that when meat is dehydrated at a drier temperature of about 50° F. and a vacuum of 29 inches Hg., the operation is too time-consuming to be practical. Factors controlling the drying rate in the freeze-drying of tissues for morphological and histochemical studies have been discussed by Gersh and Stephenson *(5)*. Gane *(4)* suggested in 1954 that freeze-drying could be used as a preliminary treatment to render the tissue porous so that subsequent drying by heated air could proceed rapidly.

EXPERIMENTAL

Material and methods. *Raw material.* Columbia and New Hampshire cross-bred female broiler chickens were used. All chickens were 3 months old and had an average weight of about 3 pounds. Upon receipt, the chickens were immediately slaughtered, eviscerated, and the breast, thigh, and leg muscles removed. All meat was frozen and stored in a 0° F. room until ready for use. In preparation for dehydration, the meat was thawed, deboned, and, when possible, the skin and fat removed. The pieces were approximately 1½ x 2 x ⅝ in. in size. These muscles were then subjected to various treatments before being dehydrated. For the main experiment, the 3 chicken muscles were treated by cooking in a minimum quantity of zeolite softened water for 15 minutes, draining for 3 minutes, and refreezing at 0° F.

The drier. The treated muscles were dehydrated in a vacuum shelf drier. The drier was equipped with both refrigeration and heating systems; the accessories included a condenser, vacuum pumps, vacuum gauges, and instruments for temperature measurements. For vacuum drying, ethylene glycol solution at —40° F. was pumped through the condenser coil and the glycol solution heated to the desired temperature was circulated through the hollow shelves of the drier. When freeze-drying was desired, the cold glycol solution was pumped through the plates as well as through the condenser. In every case the temperature of the condenser was maintained below that of the plates.

Development of a drying procedure. When this investigation was undertaken, there were no reports in the literature on the proper conditions for the dehydration of chicken meat under vacuum. It was therefore necessary that an acceptable drying procedure, which would yield a product with satisfactory color, flavor, and rehydration characteristics, should be developed before the main study could be undertaken.

A series of experiments was designed to determine the approximate drying time and drying temperature and pressure that should be used. Several arbitrarily chosen drying temperatures ranging from 68° F. to 160° F. and pressures ranging from below 1 mm. Hg. to 175 mm. Hg. were tried. After an acceptable drying procedure was established, the investigation of the factors affecting the drying rate was undertaken.

Moisture determination. The final moisture content of the dehydrated chicken meat was determined by the vacuum oven

[a] Presented at the Fifteenth Annual Meeting of the Institute of Food Technologists, Columbus, Ohio, June 13, 1955.

[b] Submitted in partial fulfillment of requirements for Ph.D. degree in Food Technology, University of Illinois, Urbana.

method. Dry chicken was ground in a Wiley mill equipped with a 20-mesh sieve. Three to five grams of sample was weighed into an aluminum dish and placed in a vacuum oven at 70° C. with the pressure below 30 mm. Hg. for 24 hours.

Rehydration ratio and organoleptic evaluation. Rehydration was conducted by placing a whole piece of dehydrated sample, which ranged in weight from 5 to 10 g. in a 250-ml. beaker with 6 times the sample weight of soft water. After soaking at room temperature for 30 minutes, it was transferred to a 500 ml. wide mouth Erlenmeyer flask. Saturated salt solution was added to adjust to about 1.5% NaCl. The flask and sample were placed on an electric hot plate and allowed to simmer at the boiling point for 30 minutes. At the end of the boiling period, the sample was drained through an aluminum screen for three minutes, the moisture that remained on the surface of the sample was blotted off with filter paper and the weight of the rehydrated sample was determined. The rehydration ratio was calculated as the ratio of the water absorbed by the dehydrated sample to the water lost by the sample during drying. The rehydrated sample combined with its liquor was used for organoleptic testing.

Blindfold organoleptic evaluation of some samples was made to estimate the effect of the different drying conditions on the dehydrated chicken product quality. Numerical values used in judging the product ranged from 1 to 10, with 10 as *excellent*, 5 as *just acceptable*, and 1 as *entirely unacceptable*. Flavor, texture, and color were the factors included in scoring. The taste panel consisted of 6 judges selected from the laboratory staff.

RESULTS AND DISCUSSION

A preliminary study of drying procedures indicated that when room temperature chicken samples were introduced into the drier, case hardening was observed in most instances regardless of drying temperature and pressure. The results with thigh and leg muscles closely paralleled the results with breast meat shown in Table 1. The extent of case hardening was greater at higher temperatures and higher pressures than in the lower ranges. Darkening of sample was also observed and the intensity of darkening increased as the drying temperature was increased.

Factors Affecting the Drying Rate

The experiments presented in this section on factors affecting the drying rate were each performed two or three times. For the most part the results of replicate experiments were quite comparable. When variation was encountered, further replication was made. Therefore, the results of only one experiment representative of all data are presented.

Temperature. Drier temperature exerted a marked influence on the rate of drying. Figure 1 represents a plot of T value (pounds of water per pound of dry solid) versus drying time for 5 different temperatures. It will be observed that an increase in temperature markedly increased the drying rate and consequently

TABLE 1

Effect of drier temperature and pressure on the dehydration of precooked chicken breast muscle

Drier temperature	Drier pressure	Drying time	Final moisture	Appearance	Case hardening
° F.	*mm. Hg.*	*Hours*	*Percent*		
160	175	8.5	31.7	very dark	excessive
160	40	9.0	24.7	very dark	excessive
106	20	10.5	39.2	slightly dark	moderate
105	0.3	10.0	7.8	good	slight
68	0.2	9.0	32.0	good	none

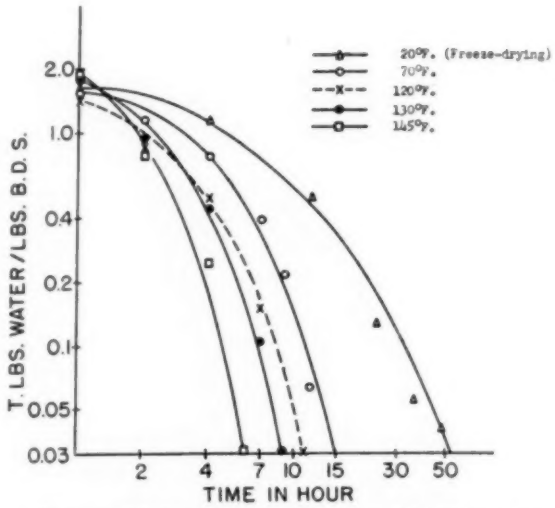

Figure 1. Effect of drier temperature on dehydration of precooked breast muscle having initial temperature of 0° F. with pressure maintained at or below 0.4 mm. Hg.

decreased the drying time. The pressure was below 0.4 mm. Hg. and the samples were in the frozen state when placed in the drier.

The interior product temperature was measured by insertion of a thermocouple, before freezing, into the approximate center of a breast muscle. The temperature during the course of drying is presented in Figure 2. The interior product remained below freezing temperature at the initial stage of drying (first 2 hours) and increased slowly as the drying progressed. After 9 hours of drying at 130° F. constant temperature, the interior product temperature reached only as high as 96° F. To this condition might be attributed the pre-

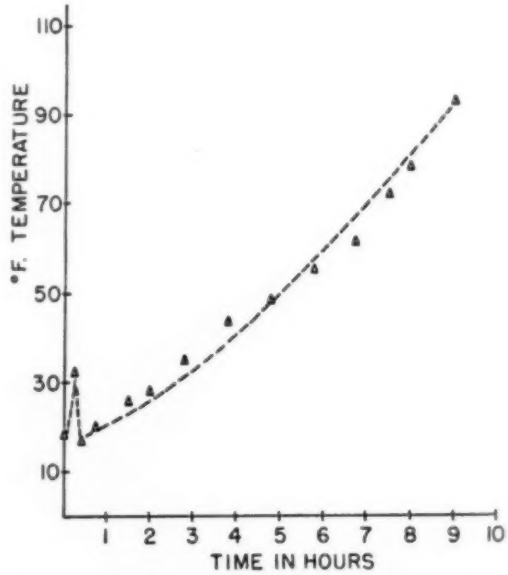

Figure 2. The change of internal temperature of precooked breast muscle during dehydration at 130° F. and 0.4 mm. Hg.

vention of heat damage to the product during drying. It is evident that a portion of the moisture in the sample was vaporized from the frozen state during the initial stage of drying. The product obtained with 130° F. tray temperature was superior to other samples. This held true for higher temperatures in respect to color and lower temperatures in respect to drying time.

Pressure. Pressures ranging from 0.2 mm. Hg. to 20 mm. Hg. were employed to determine the effect of this variable on the drying rate. Results are shown in Figure 3. It is evident that the pressure in the drier should be maintained at or below 1 mm. Hg. if low product moisture and a drying time of 9 hours is desired. Use of pressures below 1 mm. Hg. would give a factor of safety. Case hardening developed when the product was dried at a pressure of 2 mm. Hg. or higher. The development of case hardening of the sample was responsible for retarding the drying rate. From the results obtained, it can be assumed that some phenomenon such as molecular diffusion or gaseous flow of water molecules through a porous medium is the principal factor responsible for the removal of moisture in drying, rather than the lowering of the boiling point of the water in the sample. Thus, Kramer and Stemerding *(6)* reported that the partial pressure of air should be about one-hundredth of the partial pressure of water vapor at the interface. Otherwise, the rate of drying will be drastically reduced.

Initial product temperature. To avoid case hardening of sample in drying it was necessary to freeze the chicken before placing it in the drier. The effect of freezing on the rate of drying was investigated and the results were plotted as T value, lbs. moisture per lb. dry solid, against drying time. The time at which each curve crossed T = 0.05 (about 4.8% moisture) was taken as a basis of comparison. The results are given in Table 2. The drying rates in the case of the 70° F. and 32° F. initial temperatures were so low that the curves had to be extrapolated far beyond the 9 hrs. drying time actually used. However, both sets of samples that entered the drier in the frozen state, 0° F. and —40° F., reached the desired moisture content within the 9 hours. There was no marked difference in drying times within the pair of temperatures below freezing and the pair above freezing. Since the 70° F. and 32° F. samples had also been frozen and were thawed just prior to carrying out the experiment, the physical changes induced by freezing could not have caused the greater drying rate in the similar samples whose initial temperatures were —40° F. and 0° F.

A possible reason for the greater drying rate in case of the frozen sample was discussed by Cane *(1)*. During freezing, water was separated out as ice crystals which formed outside the cells and, as the drying proceeded, the rate was greatly increased because the path for the escape of water vapor was more free. This reason is based on the assumption that case hardening of the surface does not take place. Evidently this is true for freeze-dried products.

TABLE 2

Effect of initial sample temperature on dehydration of refrozen precooked chicken meat at 130° F. and 0.2 to 0.3 mm. Hg. pressure

Initial temperature	Muscle	Initial moisture content	Time in hours required to attain a moisture content of T = 0.05
° F.		*T value*	
70	Breast	1.7	35 (extrapolated)
	Thigh	1.7	25 (extrapolated)
	Leg	2.0	30 (extrapolated)
32	Breast	1.2	40 (extrapolated)
	Thigh	1.3	29 (extrapolated)
	Leg	1.5	25 (extrapolated)
0	Breast	1.6	9
	Thigh	1.6	7½
	Leg	1.7	8½
—40	Breast	1.9	8½
	Thigh	1.6	7
	Leg	1.8	7½

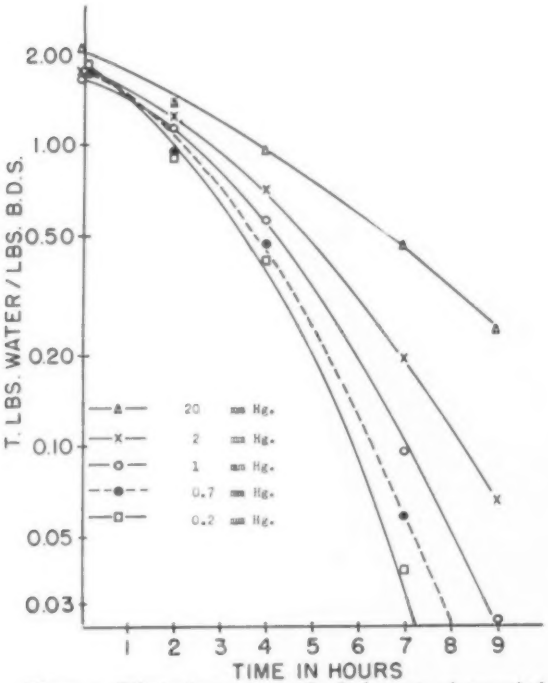

Figure 3. Effect of pressure on the drying rate of precooked leg muscles dehydrated at 130° F.

Heat transfer. A constant supply of heat was required for the vaporization of water during drying. The nature of the transfer of heat from the heated hollow shelves of the drier to the product was rather complex. Gersh and Stephenson *(5)* suggested that heat transfer during vacuum dehydration was effected by conduction and radiation from the heated plates, by conduction and convection through the air and water vapor in the drying chamber, and by conduction through the drying tissue.

Several methods were employed to compare the relative influence of radiation and conduction on the drying rate and to estimate the effectiveness of increasing heat transfer by conduction. Examination of Figure 4 shows very little difference in drying rate between (a) all radiation, sample suspended between plates, and (b) the conventional method, sample resting on shelf. This

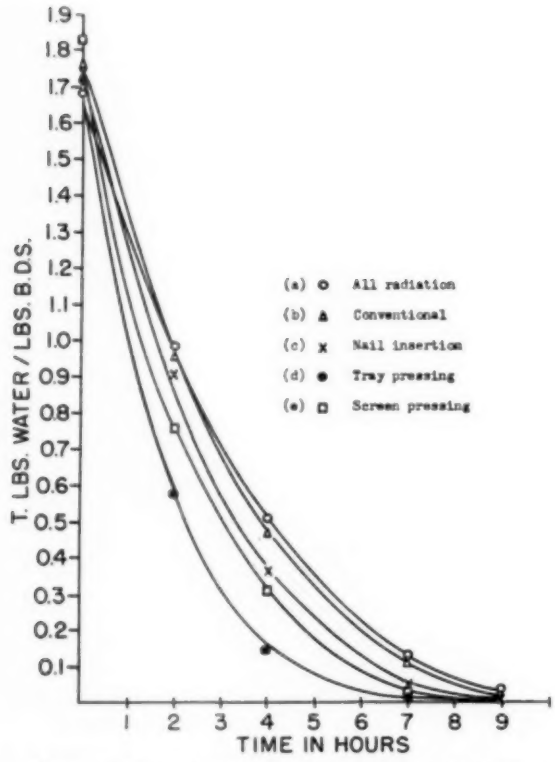

Figure 4. Effect of mode of heat transfer on the dehydration of precooked breast muscle at 130° F. and 0.4 mm. Hg.

is evidence that the means of heat transfer from the shelves to the product during conventional dehydration was predominantly by radiation. Chicken muscles are very irregular in size and in shape; hence the heat flow by conduction varied with the amount of sample area that come in contact with the heated surface. Three methods were employed to increase the surface contact area between the hot shelves and the muscle, and thus increase the flow of heat by conduction (Figure 4). These were (c) nail insertion, a 2-inch ($^3/_{16}$ in. diameter) iron nail soldered in an iron base which rested on the heated tray with the muscle impaled on the nail, (d) tray pressing, sample placed in a perforated stainless steel tray and pressed with a perforated stainless steel sheet, tray and muscle placed on heated surface, and (e) screen pressing, sample pressed flatly against the drier shelf with an aluminum screen. The results presented in Figure 4 show that these efforts to increase heat transfer by conduction were effective in increasing the drying rate during the forepart of drying. After 7 hours' drying time, the tray pressed sample showed the lowest moisture content although very little difference remained among the samples after 9 hours.

Pre-cooking. A comparison between precooked and raw samples as to their effect on the drying time is furnished in Table 3. There seems to be a slight advantage in favor of the precooked samples. This difference is probably due to the much lower initial moisture contents of the precooked samples, as shown in Table 3.

TABLE 3

Effect of precooking on the dehydration of chicken meat at several temperatures and 0.4 mm. Hg. pressure

Drying temperature	Muscle	Initial moisture content, T value		Time in hours required to attain a moisture content of T = 0.05	
		Precooked	*Raw*	*Precooked*	*Raw*
° F.					
70	Breast	1.6	2.8	12½	14½
	Thigh	1.6	3.3	12	15
	Leg	1.7	3.2	16	15
120	Breast	1.5	2.0	9	9
	Thigh	1.5	2.8	8	10½
	Leg	1.6	2.0	9	9
130	Breast	1.7	2.7	7½	9
	Thigh	1.8	2.9	6	8½
	Leg	1.8	3.1	7	8
145	Breast	1.8	2.6	7	7½
	Thigh	1.7	3.1	4½	7
	Leg	1.8	3.0	6½	7½

Initial moisture content. Even though the chickens were taken from the same lot and were approximately of the same age and weight, there were other factors inherent in the sample, such as initial moisture content and muscle thickness, which obviously influenced the rate of drying. For instance, two samples dehydrated under identical conditions for the same length of time had different final moisture contents. This difficulty has been encountered in the dehydration of many other biological materials. In this study the initial moisture content and the thickness of muscle were investigated. The results, given in Table 4, showed that within the variations in initial moisture content for precooked chicken samples presented here, there was hardly a difference in drying time between the high and low initial T values for the three muscles dehydrated at 130° F. and 145° F.

Sample thickness. The effect of sample thickness on the drying time of precooked chicken muscles is presented in Table 5. It is evident that the thinner samples of breast and leg muscles dried more rapidly. Contrary to expected results, the two thigh muscles showed no marked differences. At the end of 9 hours, the moisture contents of all samples fell in the desirable range. This may be explained on two bases. First, chicken muscles are irregular in shape and the values $^3/_8$ in. and $^5/_8$ in. represent the maximum thickness.

TABLE 4

Effect of initial moisture content on dehydration of precooked chicken muscles at two temperatures and 0.4 mm. Hg. pressure

Muscle	Drying temperature	Initial moisture content, T value	Time in hours required to attain a moisture content of T = 0.05
	° F.		
Breast	130	1.9	7
		1.6	7
	145	2.1	7
		1.8	7
Thigh	130	1.9	6½
		1.5	6½
	145	1.9	6
		1.7	6
Leg	130	2.0	6½
		1.5	5½
	145	2.2	7
		1.9	6½

TABLE 5

Effect of sample thickness on dehydration of precooked chicken muscles at 130° F. and 0.4 mm. Hg. pressure

Muscle	Thickness, inches	Initial moisture content, T value	Time in hours required to attain a moisture content of T = 0.05
Breast	⅜	1.6	9
	½	1.6	6
Thigh	⅜	1.6	7½
	½	1.6	6½
Leg	⅜	1.7	8½
	½	1.8	7½

Thus, the difference in effective thicknesses probably was not so great. Also, it is probable that some of the other variables studied, such as mode of heat transfer, are more powerful factors in determining the rate of drying under vacuum.

It is interesting to note that examination of a partially dehydrated sample showed a sharp demarcation between an outer layer of apparently dry muscle and a wet, or sometimes icy, interior.

Type of muscle. Three muscles, breast, thigh, and leg, were dehydrated. The data from this phase of the study indicated that no definite pattern existed for any specific muscle and that no one muscle was consistent in drying characteristics. In certain instances breast muscle dehydrated better than the thigh and leg, but in others thigh and leg muscle dehydrated more rapidly than breast samples. Thigh and leg muscles did not always show similar drying characteristics.

Organoleptic tests and rehydration ratios. As was discussed previously in connection with Figure 1, the overall drying rate was markedly influenced by the drier temperature. Freeze-drying at 20° F. was especially time consuming. The question arises, does an increased product quality compensate for the greater processing expense at the lower drier temperatures? Preliminary evidence in answer to this question is presented in Table 6, wherein the color, flavor, texture scores, and rehydration ratios for the three muscles, pre-cooked and raw, dehydrated at freezing temperature to 130° F. are given. The scores are averages of blindfold taste panel results and also include fresh chicken samples. No storage period was involved in this study.

A statistical analysis of the data in Table 6 is presented in Table 7. A starred number shows that the factor or combination of factors represented by that row had a statistically significant effect, at the 1% level, on the characteristic represented in that column. Thus, the

TABLE 7

Analysis of variance of organoleptic scores and rehydration ratios as affected by muscle, precooking, and dehydration temperature

Factor	d f	Color M. S.	Flavor M. S.	Texture M. S.	Rehydration ratio M. S.
Muscle (M)	2	1.89*	0.34	0.48	315
Control vs. Dehydrated (A)	1	0.08	1.43	1.60	
Cooked vs. Raw (C)	1	.77	.28	6.41*	2
Dehydration Temperature (T)	3	.25	.15	0.63	288*
M A	2	.20	.08	.22	
M C	2	.30	.28	.89	249*
M T	6	.25	.16	.42	84
C T	3	.03	.56	.85	193
M C T	6	.15	.27	.40	47
	26				

d f = Degrees of Freedom.
M.S. = Mean Suare.
* = Significant at the 1% Level.

TABLE 6

Organoleptic test scores and rehydration ratios

Muscle	Treatment	Dehydration temperature	Color	Flavor	Texture	Rehydration ratio, percent
Breast	Cooked	Freeze-Drying	8.8	8.2	7.4	74
Thigh	Cooked	Freeze-Drying	8.7	7.9	8.1	57
Leg	Cooked	Freeze-Drying	7.6	7.8	7.6	52
Breast	Raw	Freeze-Drying	8.2	7.2	6.4	68
Thigh	Raw	Freeze-Drying	7.8	7.2	7.6	73
Leg	Raw	Freeze-Drying	7.6	8.2	7.2	62
Breast	Cooked	70° F.	9.2	7.5	8.2	76
Thigh	Cooked	70° F.	7.6	7.0	8.0	49
Leg	Cooked	70° F.	8.5	8.0	8.6	63
Breast	Raw	70° F.	8.0	7.8	5.8	57
Thigh	Raw	70° F.	7.5	7.8	6.6	70
Leg	Raw	70° F.	8.3	8.7	7.6	65
Breast	Cooked	120° F.	8.8	7.0	9.0	77
Thigh	Cooked	120° F.	7.2	7.0	6.7	55
Leg	Cooked	120° F.	8.3	7.5	8.2	69
Breast	Raw	120° F.	7.8	7.8	5.4	49
Thigh	Raw	120° F.	8.0	8.0	6.8	48
Leg	Raw	120° F.	7.8	7.5	6.5	53
Breast	Cooked	130° F.	9.4	8.4	8.2	89
Thigh	Cooked	130° F.	7.9	7.8	7.5	60
Leg	Cooked	130° F.	8.4	7.0	8.2	65
Breast	Raw	130° F.	9.0	7.8	8.0	89
Thigh	Raw	130° F.	7.9	7.3	7.0	61
Leg	Raw	130° F.	8.2	8.4	8.4	86
Breast		Fresh Control	9.3	8.1	8.3	—
Thigh		Fresh Control	8.0	8.4	8.4	—
Leg		Fresh Control	7.8	8.8	8.0	—

type of muscle had a significant effect on the organoleptic color. The average color score for breast muscle, 7.7 was superior to that for dark muscles, which was 7.0. The chances are only 1 in 100 of finding so large a difference purely by chance. The difference in texture between cooked and raw samples was also significant, their respective average scores being 8.0 and 7.0.

Failure to find a significant difference may also be important. Perhaps the most interesting result was that dehydration temperature, within the limits studied, had no significant effect on any of the three organoleptic evaluations. Only in the case of rehydration ratio did dehydration temperature have a significant effect, the samples dehydrated at 130° F. showed a superior rehydration characteristic with an average of 75% as compared to an average of 62% for all the lower temperatures. Therefore, use of plate temperatures as high as 130° F. is warranted.

Also noteworthy was the general lack of significant differences between the average organoleptic scores for all dehydrated samples and those for the undehydrated controls. This shows that the original product quality was not degraded during preparation and dehydration. Further work will be required to determine what effect storage would have on this comparison.

SUMMARY AND CONCLUSIONS

A preliminary study was carried out to establish an acceptable drying procedure. Tray temperature markedly affected the drying rate. As tray temperature was increased to 145° F. the drying rate increased. However, a temperature of 130° F. was most desirable from product quality and quite acceptable from drying rate standpoints.

The drier pressure also strongly affected the drying rate. When a tray temperature of 130° F. was used, pressures at or preferably below 1 mm. Hg. resulted in rapid drying rates and absence of visible case hardening. Under these conditions a drying time of 7 hours was sufficient to dehydrate the sample to less than 5% moisture.

An initial product temperature of 0° F. gave better drying rates than resulted from higher temperatures, but −40° F. was of no apparent advantage.

The results indicated that the usual mode of heat transfer to the chicken was predominantly by means of radiation. When heat transfer by conduction was increased the drying rate was noticeably raised. Results of this work indicated that opportunity to increase the drying rate lies in this area.

Other factors studied, such as pre-cooking, initial moisture content, and sample thickness within the limits studied did not have marked effects on drying rate. Statistical analysis of organoleptic and rehydration data arising from an experiment designed to study the effect of dehydration temperature showed that low drier temperatures, including freeze-drying, presented no apparent product quality advantage compared to 130° F. The finished product obtained in this experiment rehydrated satisfactorily and its organoleptic quality compared favorably with that of undehydrated controls.

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Observations on Black Pepper
I. Analysis of Bite Principles[a]

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Piperine is known to be an important principle contributing to bite in black pepper. The effect of light on piperine in two different solvents was studied. Benzene is shown to be a better solvent than chloroform for the spectrophotometric determination of piperine in oleoresins of black pepper. Oleoresin of black pepper has been fractionated by molecular distillation and the heat value of each fraction compared with piperine content as measured by the spectrophotometric and Kjeldahl total nitrogen methods. Heat is found to correspond to spectrophotometric piperine, whereas large variations from Kjeldahl piperine are noted.

Black pepper has been and still is the most important spice of our globe. Not only have perilous voyages been undertaken and fierce battles fought for control of this condiment, but at periods in our history pepper has even served as a currency. Therefore, it is not surprising that the chemistry of the active constituents of black pepper was studied at an early date.

Our knowledge of the chemistry of black pepper dates back to 1820 when crystalline piperine was isolated by Oersted *(6)*. In 1821 Pelletier *(11)* found that piperine was not a base, and was the first to recognize that it is not the only bite principle of pepper. The structure of piperine was definitely established by total synthesis by Ladenburg and Sholtz *(4)* in 1894. In 1876 Buchheim *(1)* investigated the liquid portion of the oleoresin after separating piperine. He found that this dark resin, which he named chavicine, produced a far greater bite sensation on the tongue than crystalline piperine. He concluded that chavicine, and not piperine, was the more active bite principle in black pepper. Extensive investigations of the structural relationship between piperine and chavicine revealed the latter to be the *cis-cis* isomer. This work has been well covered in a review by Newmann *(5)*.

This initiated the controversy on which was the principle heat factor in black pepper, piperine or chavacine. Ott and co-workers *(8, 9, 10)* demonstrated the strong bite of chavicine per se and proposed that the heat of piperine in alcoholic solution was due to residual traces of the *cis* isomer. Other workers such as Staudinger *(15)* and Rheinbolt *(12)* demonstrated that very carefully purified piperine retained high bite in finely dispersed form as well as in solution. However, no quantitative organoleptic heat tests comparing the total heat of piperine and chavicine in solution have been made, and in most publications chavicine is quoted as being the more pungent.

Black pepper as a spice is used for heat as well as aroma and flavor. Since piperine is universally accepted as the predominant bite principle in black pepper, oleoresin quality is often based on piperine content. The present chemical method for determining piperine is based on total nitrogen determination. This method is subject to variation due to other nitrogen-containing compounds, and permits easy adulteration with foreign nitrogenous materials. An organoleptic assay for heat as used for red pepper *(13)* has the great disadvantage of inherent human inaccuracy. A simple, accurate, analytical method as a true measure of pungency was therefore desired. A method of piperine assay, based on spectrophotometric measurements, was developed in our laboratories. While the work described below was underway, a paper[c] by Fagen, Kolen and Hussong *(2)* of the Kraft Food Research Laboratories, described an almost identical method. Discrepancies between the spectrophotometric and Kjeldahl methods for piperine were ascribed to chavicine. However, since no comparison with heat was given a correlation between chemical analysis and heat level in oleoresin of black pepper was still lacking.

EXPERIMENTAL

Materials and methods. All solvents used for the spectrophotometric determinations were reagent grade and transmittance was checked before use.

Piperine, M.P. 129.4-130.2° C. (264.9-266.3° F.), was isolated from oleoresin of Malabar black pepper and purified by repeated recrystallization, first from isopropyl alcohol, then from ethyl acetate.

The starting oleoresin used in this study was extracted with ethylene dichloride in a Soxhlet apparatus from Malabar black pepper. Subsequently, the solvent was partially removed in vacuo and a large part of the piperine was allowed to crystallize. The piperine was removed by filtration and the filtrate stripped of remaining solvent and the more volatile oil fractions in vacuo. The resulting viscous, liquid material—hereafter called oleoresinous fraction—had a total nitrogen content (N) of 2.33%, equivalent to 47.5% piperine. All spectrophotometric measurements were made on a Model DR Beckman Recording Spectrophotometer. One-centimeter matched silica cells were used.

A centrifugal still, Model CMS-5, with 5 inch aluminum rotor, by Distillation Products, Inc., was used for molecular distillation. Total N was measured by the Kjeldahl method *(7)*. Heat value was measured by a modified Scoville method *(13)* where 3% instead of the usual 10% sucrose solution was used to attain higher sensitivity. The dilution at which bite was just perceptible was taken as the criteria.

Effect of light and solvent on transmittance measurements. Pure piperine (68.8 mg.) was dissolved in 100 ml. of chloroform in a volumetric flask in a semi-darkened room. One ml. of this solution was further made up to 200 ml. with chloroform and the absorption curve of the final solution, containing 3.44 mg./l. of piperine, was determined. The solution was then exposed continuously to light; indirect diffuse sunlight during the day and fluorescent light during the night. Absorption curves were rerun at intervals and decrease and shift in the principal absorption maximum was noted. All studies were made at room temperature which varied from 23° to 28° C. (73° to 82° F.).

[a] Presented before the Fifteenth Annual Meeting of IFT, Columbus, Ohio, June 13, 1955.

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[c] Presented at the Spring Meeting (1955) of the American Chemical Society.

A benzene solution containing 3.36 mg./l. of piperine was exposed to identical conditions and examined in a like manner.

A concentrated solution of piperine in chloroform (688 mg./l.) was likewise exposed to these light conditions for an extended period and transmission measurements made every 24 hours on aliquots after dilution.

Solutions containing 3.12 mg./l. piperine in chloroform and 5.04 mg./l. piperine in benzene were kept in the dark and the transmittance measured regularly, first every 2 hours, then every 24 hours. At the end of 72 hours no change in transmittance values in either solvent could be detected.

Molecular distillation of oleoresin black pepper. An attempt to fractionate the oleoresinous fraction by distillation at 0.1 mm. Hg. pressure in a round bottom flask failed, since only the normally steam volatile material distilled while the residue decomposed and resinified. Therefore, a 990 g. sample of the oleoresinous fraction was subjected to molecular distillation.

At the beginning of the distillation the best obtainable vacuum was 0.2 mm. Hg. This was due to a large amount of volatile oil, which had purposely not been removed from the oleoresinous fraction to prevent resinification. Four oil portions, which volatilized at rotor temperatures of 80-120° C. (175-248° F.), pressures between 1 mm. and 0.1 mm. Hg. were collected in the dry ice trap. N content of the forerun was less than 0.05%, equivalent to 1% piperine. The first distillate fraction, collected at the above temperature and pressure, contained 4.5% apparent piperine. Total weight of forerun plus first fraction was 259.4 g. (26.2%). After removal of volatiles the distillation proceeded without difficulty and 8 fractions were collected (Table 1).

The piperine content of each fraction was determined by the Kjeldahl and spectrophotometric methods and compared with Scoville heat. Results, together with values for original oleo fraction, are shown in Table 2.

Fractionation of distillate fractions No. 2 and No. 3. Portions of distillate fractions No. 2 (58.63 g.) and No. 3 (49.59 g.) were combined and triturated with three 200 ml. portions of ethyl ether, leaving 26.27 g. of crude piperine, which melted at 123.0-126.0° C. (253.5-259° F.), undepressed upon admixture of an authentic sample. The ether soluble portion, dissolved in 150 ml. ether, deposited 17.67 g. of yellow waxy solid on standing at —15° C. (5° F.) overnight. The solid was filtered, and the dark, orange-colored, viscous liquid filtrate (56.35 g.) was subjected to a crude counter-current distribution between 300 ml. portions of n-pentane and 85% methanol in 6 one-liter separatory funnels, using a "diamond" pattern (16). Six methanol soluble (polar) fractions, total weight 33.23 g., and six pentane soluble fractions, total weight 23.05 g., were obtained. The main fractions of methanol soluble material and pentane soluble material were analyzed for piperine and heat.

TABLE 1

Molecular distillation of oleoresin black pepper

Fraction	Temperature ° C.	Pressure mm. Hg.	Weight		Description
			g.	Percent	
Forerun	80–120	1–0.1	234.7	23.8	Greenish-yellow oil
1	80–120	1–0.1	24.7	2.5	Greenish-yellow oil
2	120	0.1	64.4	6.5	Yellow oil
3	135–140	0.014–0.030	65.1	6.6	Orange oil and solid
4	145–148	0.011–0.014	63.0	6.4	Yellow, semi solid
5	150	0.01–0.012	57.3	5.8	Yellow, semi solid
6	150	0.008–0.01	75.7	7.6	Yellow, semi solid
7	150	0.006–0.008	68.2	6.9	Orange, semi solid
8	160	0.006–0.008	31.1	3.1	Orange, semi solid
9	170	0.007	32.0	3.2	Dark orange, semi solid
Residue			213	21.5	Black, hard tar

TABLE 2

Characteristics of fractions described in Table 1

Distillate fraction	Piperine		Scoville heat value
	Kjeldahl	Spectrophotometric	
	%	%	
1	4.5	0.8	2,000
2	13.3	3.2	6,000
3	40.4	13.5	25,000
4	67.7	31.3	50,000
5	78.6	40.2	75,000
6	79.0	41.1	75,000
7	80.0	46.0	100,000
8	78.3	51.5	80,000
9	75.8	48.8	80,000
Residue	60.5	18.8	17,500
Controls			
Piperine	100.0	100.0	200,000
Starting Oleoresinous Fraction	47.5	23.1	50,000

RESULTS AND DISCUSSION

The apparent loss of piperine in dilute chloroform solutions as effected by light has also been pointed out by Fagan *et al. (3)*. However, it is interesting to observe piperine loss in benzene when compared with chloroform. Figure 1 shows the difference in rate of loss of piperine at comparable levels in both solvents based on transmittance studies at 342 mμ. It also shows that deterioration is far slower in chloroform at higher concentration. The dilute chloroform solution had lost 49% in 7 hours, after which piperine concentration remained practically constant. Loss in benzene after 7 hours was only 28%, equilibrium was established at

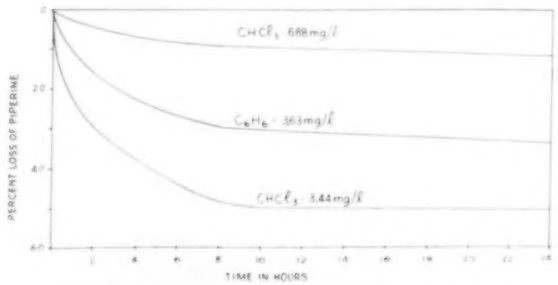

Figure 1. Effect of light on piperine in solution.

40% after three days. Of particular importance is the appreciable difference in deterioration in the two solvents during the first 5 or 10 minutes, since some exposure to light is difficult to avoid in routine determinations. Solutions of piperine in methanol and isopropanol gave absorption curves identical to that of the chloroform solution in the region studied. However, these alcohols were dismissed as solvents for routine determinations because of low solvent power for piperine.

Absorption curves showing the effect of light and time on piperine in chloroform solution are given in Figure 2. Of interest in this group of curves is not only piperine loss, but also shift of the absorption maximum from 342 mμ to 330 mμ. This leads one to speculate on the fate of the disappearing piperine. It is suggested that piperine loss could be accounted for by a light-induced *cis-trans* isomerization to chavicine, and that chavicine could be responsible for the shift to shorter wave length.

To date chavicine has not been obtained in a pure state; hence, its ultraviolet spectrum is not known. Work is underway on isolation of the light-exposed sample of piperine and this will be followed by an attempted characterization of the breakdown products.

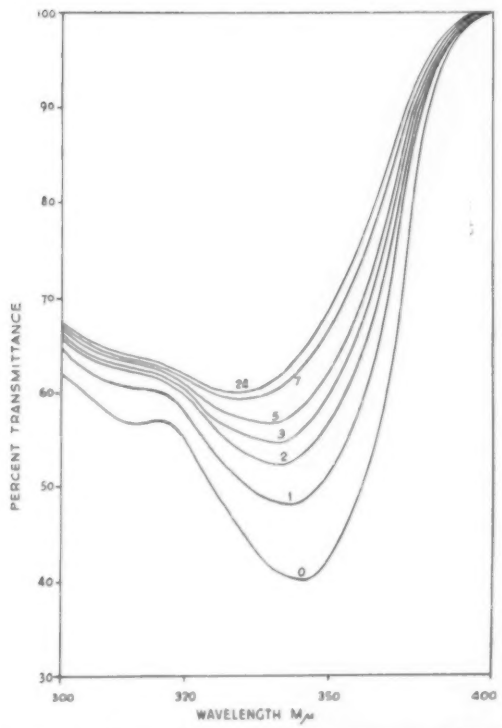

Figure 2. Effect of light on absorption spectrum of piperine in chloroform. Nos. indicate time of light exposure in hours.

Molecular Distillation of Oleoresin Black Pepper

The oleoresin of Malabar black pepper was stripped of volatile oil and piperine containing precipitate, then fractionated by molecular distillation into 9 fractions and a residue. The temperatures and pressures characterizing these fractions are shown in Table 1.

Kjeldahl and spectrophotometric piperine as well as Scoville heats were run on each of the 9 fractions and on the residue (Table 2). Examinations of the data show that there is good agreement between spectrophotometric piperine and Scoville heat. The Scoville heat value of pure piperine is 200,000. The Kjeldahl piperine is constantly higher than the spectrophotometric piperine. For example, in fraction 8 it is 1.5 times as high and in fraction 3 it is 3 times as high. Apparently, a nitrogenous source not contributing heat is interfering in these instances.

The distillation residue presents a special study. Analysis shows a spectrophotometric piperine of 18.8% which should yield a Scoville heat of 37,600, but it shows only 17,500. An absorption curve of this residue, shown in Figure 3, indicates that half of the absorption at 342 mμ may be due to piperettine, a piperine analog known to have an absorption maximum at 360 mμ *(14)*.

Heat value of piperettine has not been reported; but if this were assumed to be low, it could account for the differences. Piperettine is a minor constituent of oleoresin black pepper and hence would not contribute an appreciable source of error there, but it could be significant when it is more highly concentrated in the distillation residue.

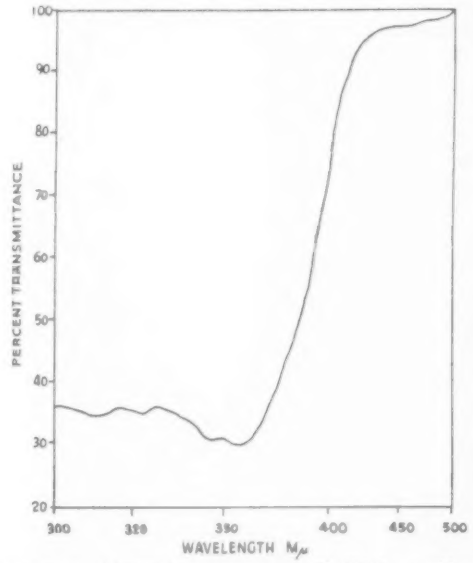

Figure 3. Absorption spectrum of distillation residue.

Fractionation of distillate fractions. To emphasize the difference between spectrophotometric and Kjeldahl piperine, portions of distillate fractions No. 2 and No. 3 were further fractionated. Figure 4 shows the separation scheme used; the results obtained are given in Table 3. It is apparent that there are several nitrogenous compounds different from piperine, all of which possess very little or no heat. The ratio is Kjeldahl to spectrophotometric piperine in Fraction II, a waxy solid, is nearly 8 to 1. Fraction IV A, a liquid material soluble in pentane with a Kjeldahl piperine content of 37.9%, shows no absorption at all at 342 mμ. Correlation between heat value and spectrophotometric piperine

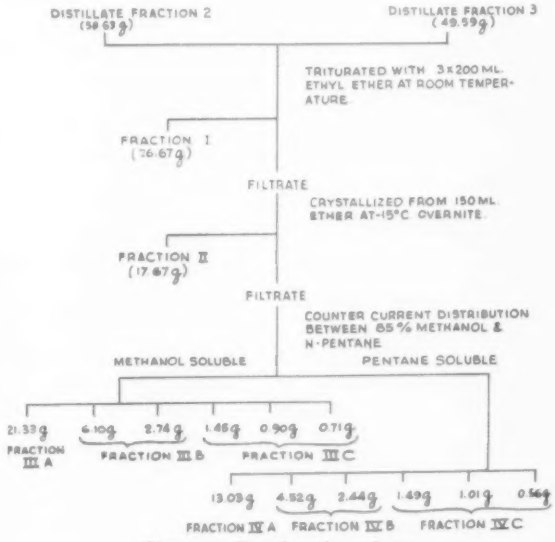

Figure 4. Fractionation scheme.

TABLE 3
Characteristics of fractions described in Figure 4

	Piperine		Scoville heat value
	Kjeldahl	Spectrophotometric	
	%	%	
Fraction I	99.2	92.0	200,000
Fraction II	70.8	8.9	20,000
Fraction III A	86.5	32.1	60,000
Fraction III B	84.4	29.7	55,000
Fraction IV A	37.5	<0.1	<1,000

is excellent, well within the limits of accuracy of the organoleptic method. No further work on these fractions was carried out and the chemical nature of the compounds remains to be elucidated.

It is interesting to note that Fractions III A and III B, which correspond to crude chavicine as isolated by Ott and Eichler *(8)*, have heat values of 60,000 and a spectrophotometric piperine content of about 30%. Work is in progress on the purification of this material and results will be reported later.

SUMMARY AND CONCLUSIONS

The effect of light on the absorption spectrum of piperine in solution was studied. The rate of piperine loss, based on transmittance studies at 342 mμ, was far less for benzene than for chloroform solutions. This is particularly obvious during the first 15 minutes of exposure to light conditions found in the average laboratory. Concentrated solutions were less light sensitive. The solubility of piperine in methanol and isopropanol was too low to permit satisfactory use of these solvents. In view of the difficulty of complete light protection for piperine solution in routine analysis, benzene is recommended as the solvent for conducting spectrophotometric piperine determinations.

One fraction of an oleoresin of Malabar black pepper was further fractionated by molecular distillation, crystallization and crude counter-current distribution. Each fraction was analyzed for heat and for piperine by Kjeldahl and spectrophotometric methods. Large variations between the two methods of piperine determination noted in the original oleoresin are emphasized in the fractions. Heat values were in good agreement with spectrophotometric piperine in each fraction. Therefore, piperine content determined spectrophotometrically is a good measure of heat content of oleoresin of black pepper.

Acknowledgment

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A Simplified Variables Taste Panel Method for Detecting Flavor Changes In Vegetables Treated with Pesticides[a, b]

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Tremendous effort is being expended currently by industry, Government, and other research agencies on the investigation of newly developed pesticides as possible causes of off-flavor in food products *(9, 10)*. Essentially, the purpose is to determine whether the application of a given pesticide in such quantities and at such times that will provide adequate pest control will or will not impart an off-flavor to the end food product to a commercially significant extent.

In order to achieve this purpose completely, investigations of this nature should be designed in such a way that the results will provide the answers to the following questions:

Does the application of the pesticide result in a *real* difference in flavor?

Is the difference, if any, commercially important?

Is the difference good or bad?

Significant difference. Progress in the field of taste testing has reached the point where many workers are now cognizant of the fact that research of this nature, as well as any other, must be conducted in such a way that the results may be analyzed statistically. Statistical treatment is required in order to determine whether the differences that are reported are real or merely due to chance variation. Many designs and procedures are available which make possible the statistical evaluation of taste panel data *(5, 11, 14)*.

It should be noted, however, that statistical analysis can never be submitted as proof that differences do not exist. Where statistical significance has not been obtained, say at the 5% level, it may be stated that *under the conditions of the experiment* the odds in favor of there being a real difference between the samples were not sufficiently high to justify the conclusion that those differences are not due to chance variability. However, if the experiment should be extended, the added precision gained from this additional work might produce a statistically significant result. Indeed, if the experiment were to be repeated *ad infinitum*, a statistically significant difference would always be found, since any two things are bound to differ in some respect even though that difference may be unimportant from the practical standpoint.

The various methods by which precision may be improved so that significant differences may be obtained may be classed as follows:

Increasing the number of judges and replications
Training and selection of judges
Improving the homogeneity of the samples
Improving the conditions of the test
Selection of an efficient statsitical design

Commercial importance. Any one or any combination of the above methods may be used in order to obtain differences that are statistically significant at any desired level of precision. The question is: what is the desired degree of precision? In the pursuance of these investigations, is it necessary to determine whether there is any flavor difference that is detectable, though not necessarily objectionable, to less than 1% of the population? It is safe to assume that under ordinary circumstances such precision is unnecessary.

The degree of precision that is required, however, should be determined in advance, and the experiment should then be designed in such a manner that the required degree of precision is attainable.

Is the difference good or bad? In many flavor evaluation studies, it is unimportant to determine whether the test sample (or samples) is poorer or better in flavor than the reference sample *(13)*. In other studies *(9, 10)* it is assumed that any real difference that is obtained is in an undesirable direction. Such an assumption is not always correct, as was demonstrated in an experiment with cantaloupes where malathion was applied in three ways—as a spray, as a dust, and as aerosol. Actually, an improvement in flavor was indicated whenever the pesticide was used; it was also shown that the flavor of the sprayed cantaloupes was superior to the dusted or aerosol treated product, as follows:

Malathion applies as:	Flavor value*
Dust	0.3
Spray	1.0
Aerosol	0.4
Check	0.0
Least significant difference	0.3

*A higher score indicates better flavor.

The F value of 10.33 indicated statistical significance well beyond the 1% level.

Testing by attributes. In any application of statistical quality control, one of the first decisions to be made is whether the procedure should be based on attributes, or variables criteria *(12)*. For purposes of taste panels, an attributes procedure may be defined as one which calls for the mere selection or identification of a sample, whereas a variables procedure requires the evaluation of each sample on the basis of some predetermined scoring system.

Attributes procedures are generally applied where direct measurements are not possible, or impractical, or where statistical calculations must be held to a minimum *(12)*. It was thus logical to assume that such procedures would be proper for determining so elusive

[a] Scientific publication A468, Contribution No. 2550, of the Maryland Agricultural Experiment Station (Departments of Horticulture and Entomology).

[b] Presented in part at the Fourteenth Annual Meeting of the Institute of Food Technologists, Los Angeles, California, July 1, 1954.

a quality as flavor. Also, as a first step in the direction of a statistically valid test procedure, the almost total absence of the need for mathematical calculations was very attractive.

In practice, the attributes criterion was found to be quite useful where samples approach complete homogeneity, where it is advantageous to refer continuously to a control sample, and where the purpose of the test is primarily to detect differences per se, rather than to evaluate the meaning of the differences. Such conditions are met in the distillery industry where a modification of the triangular method is used to good advantage *(13)* in flavor studies.

Testing by variables. In the evaluation of flavor changes resulting from the application of pesticides to growing crops, however, such conditions may not be met. Homogeneous samples are a rarity, and the ultimate purpose of the test is not mere detection of differences but an evaluation of the differences for practical purposes.

Thus for the purpose at hand it may be well to consider the use of a variables, that is, a scoring method, especially since a variables method is, theoretically at least, much more precise than an attributes plan. Grant *(8)* shows that as much information may be obtained from 4 tests using a variables criterion, as from 10 tests using an attributes criterion. As the total number of tests increases the difference in favor of the variables criterion becomes ever greater. Thus, for example, the same information may be obtained from 30 tastings provided, say, by 15 judges scoring two samples, as might be obtained by an attributes procedure consisting of some 270 individual testings where 15 judges are required to taste 6 sets of 3 samples each.

In a variables method, actual values are assigned to two or more samples, each of which may be replicated any given number of times, depending on the precision desired. The statistical procedure employed here is the analysis of variance *(16)*, which may be utilized with many degrees of complexity.[c] (In its simplest form, it may be described as a ratio of the variability arising from the differences among the samples tested as compared to the variability arising from differences among the replicates of each sample. Thus the greater the variance among the samples and the smaller the variance among the replicates of each sample, the greater the odds that the differences among the samples are real, and not due to chance variability.)

Recognizing the fact that a serious obstacle to the use of such a variables method is the expense and difficulty of carrying out the computations under practical conditions, the following simplified procedure is suggested, based on analysis from the range, as developed by Tukey *(15)*.[d]

Our example consists of 3 samples of canned pears. Sample A is the check, and samples B and C were treated with different pesticides. Fifteen judges scored each sample in duplicate on the basis of a 5-point scale, where +2 indicated entirely acceptable flavor, +1 probably acceptable flavor, 0 questionable flavor, −1 probably off-flavor, and −2 definitely off-flavor. The averages of the duplicate scores for each sample, as provided by each judge, are presented in Table 1. First the totals for each sample are obtained, and the range between the highest and lowest totals determined. Since 15.5 (sample A) was the highest, and 6.5 (sample C) was the lowest of the sample totals shown in Table 1, the range among the samples is 15.5 — 6.5 or 9.0.

We then obtain the range within each sample by subtracting the highest single judge's average score from the lowest for the sample. Thus the range for sample A is 2.0 — 0.5 or 1.5; for sample B it is 1.5 — (— 0.5), or 2.0; and for sample C it is 1.0 — (—1.5), or 2.5, and the sum of the ranges for all the samples is 6.0. We now enter Table 2, and find that for a sample number of 3, the factor for determining whether there is a real difference among the samples (at the 5% level) is 1.2. Since the sum of the ranges within the samples of 6.0 multiplied by the factor of 1.2, is 7.2 which is smaller than the range among the sample totals of 9.0, we may conclude that there is a real difference among the samples.

TABLE 1

Analysis of variance from the range of the scores of 15 judges for three samples of canned pears (averages of duplicate scores where 2 = good flavor, 1 = acceptable, 0 = questionable, —1 = slight off flavor, and —2 = definite off flavor)

Judges	Sample scores			
	A	B	C	
1	1.5	0.5	0.5	
2	2.0	1.0	1.0	
3	1.5	1.0	1.0	
4	0.5	0.5	1.0	
5	1.0	0.5	0.5	
6	0.5	0.0	1.0	
7	2.0	1.5	1.0	
8	0.5	0.5	0.5	
9	1.5	1.0	0.0	
10	0.5	0.0	0.0	
11	1.0	1.0	−1.5	
12	0.5	1.0	0.5	
13	0.5	−0.5	0.5	
14	1.5	0.5	1.5	
15	0.5	0.5	−1.0	
Totals	15.5	9.0	6.5	15.5 − 6.5 = 9.0
Ranges	1.5	2.0	2.5	6.0 × 1.2 = 7.2

Since the range among totals (9.0) is greater than the sum of ranges × factor (7.2), the difference among samples A, B, C is real, and 6.0 × 1.0, or 6.0 is the difference required for significance among the totals.

TABLE 2

Factors to be used for multiplying the sum of ranges in order to determine significance of differences from the range, when using 5 to 15 judges

Number of samples	Factor for determining if any of the sample totals are really different	Factor for determining the least significant difference (L.S.D.)
2	1.5	1.5
3	1.2	1.0
4	1.0	0.75
5	0.8	0.6
6	0.7	0.5
7	0.6	0.4
8	0.55	0.35
9	0.5	0.30
10	0.45	0.27

[c] Some limitation on the use of the analyses of variance have been pointed out. See references *(1, 3, 7)*.

[d] Where additional computations do not present a serious problem, the standard method of computing the analysis of variance is of course preferable to the approximate range method.

We may now enter Table 2, and find that for a sample number of 3, the factor for determining the least significant difference is 1.0; hence, 6.0 (sum of ranges within the samples) × 1.0 equals 6.0, which is the least significant difference (L.S.D.) among the sample totals. We may therefore conclude that the results of the panel indicate that the flavor of sample A is superior to that of samples B and C, which in turn, were not found to be significantly different from each other.

These total scores and the L.S.D. (least significant difference) value of 6.0 may now be divided by the number of judges, in order to obtain average scores for each sample as follows:

Sample	Average score
A	+1.03
B	+0.60
C	+0.43
L.S.D.	0.40

We may now conclude that the pesticides used had a real effect on reducing the excellence of the flavor of the canned pears as tested by the above panel. However, since all the values are positive, it may be assumed that the flavor of all the samples was satisfactory, so that a recommendation for rejecting the use of these pesticides on pears is not justified solely on the basis of the above data. Nevertheless, since the flavor of the pears was depressed significantly, more elaborate tests are in order.

This use of an average value carries with it a most important qualification; namely, that there be no significant interaction between judges and samples. This means that such average scores may be used only if all judges, or at least the great majority of judges, score all the samples in a similar manner. This may not always be so, especially with those studies where individual responses to flavor changes imparted by pesticides are known to vary considerably. A situation of this kind is demonstrated in Table 1. Although, on the average, the flavor of sample C was considered acceptable, it was scored as decidedly off-flavor by judges 11 and 15, although judges 6, 13, and 14 scored sample C as superior to sample B. In such instances, additional testing is required before a pesticide may be rejected or cleared for use.

An adaptation of this same range method may serve as a convenient means of evaluating the ability of individual judges to detect differences. This is demonstrated in Table 3, using the same data on canned pears. Here the data provided by each judge is computed separately. First, the range among sample totals for each judge is determined. For example the sums for judge number one are 3 for sample A, 1 for sample B, and 1 for sample C. Thus the range is 3 — 1, or 2. Next the sum of the ranges between duplicates is obtained, which in the case of judge number one is (2 — 1 for sample A) + (1 — 0 for sample B) + (1 — 0 for sample C), or 3. The ratio of the range among samples to the range within samples for judge number one is therefore $\frac{2}{3}$, or 0.67. The higher the ratio, the greater is the indicated ability of the judge to discriminate among the samples; consequently, the judge showing the highest ratio may be ranked as first, and the others may follow in descending order in accordance with the value of this ratio.

This example is not intended to indicate that the judge who ranked highest in this particular experiment has proved beyond doubt that he is the best judge for this particular purpose. However, the compilation of records of this nature will in a short time provide the responsible taste panel worker with much valuable information concerning the abilities and shortcomings of panel members at his disposal.

DISCUSSION

The results presented in Table 4 cover the tasting of 5 products by both the triangular (an example of an attributes method) and the proposed variables method. For each product, the triangular tests numbered 560 individual tastings, while for the variables test 140 individual taste scores were recorded. It may be noted that results with the triangular attributes method yielded 6 significant values while those with the variables technique resulted in 7 significant values, although only one-fourth as many tastings were utilized. It

TABLE 3

Ranking of fifteen judges scoring three samples of canned pear in duplicate (2 = good flavor, 1 = acceptable, 0 = questionable, —1 = slight off-flavor, —2 = definite off-flavor)

Sample	Duplicate	Judges														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	1	1	2	1	0	2	1	2	—1	0	—1	2	1	1	1	1
	2	2	2	2	1	0	2	2	2	1	2	0	0	0	2	0
B	1	0	1	2	1	0	0	2	1	1	1	1	1	—1	0	1
	2	1	1	0	0	1	0	1	0	1	—1	1	1	0	1	0
C	1	0	1	1	1	1	1	1	1	1	—1	—1	1	1	1	—1
	2	1	1	1	1	0	1	1	2	—1	1	—2	0	0	2	—1
Range among samples (difference between largest and smallest sums of A, B, or C)		2	2	1	1	1	3	2	0	2	1	5	1	2	2	3
Range between duplicates (sum of differences between duplicate 1 and 2)		3	0	3	2	4	1	1	7	3	7	3	2	3	3	2
Ratio: range among samples/range between duplicates		.67	∞	.33	.50	.25	3.00	2.00	.00	.67	.13	1.67	.50	.67	.67	1.50
Rank		6	1	12	10	13	2	3	15	6	14	4	10	6	6	5

TABLE 4

Summary of triangular (attributes) and multiple comparison (variables) taste test results of 5 processed vegetables treated with pecticide aerosols

Treatments	Products									
	Tomato juice		Tomatoes		Potatoes		Snap beans		Lima beans	
	Triangular	Mult. comp.	Triangular	Mult. comp.	Triangular	Mult. comp.	Triangular	Mult. comp.	Triangular	Mult. comp.
Toxaphene 2%	10	0.3	10	0.4	16[1]	1.2[2]	10	0.4	15	0.1
Methoxychlor 2%	16[1]	0.8[2]	12	0.0	13	0.3	10	0.8	18[1]	0.0
Malathion 4%	11	0.4	14	0.7	13	0.2	11	0.6	15	0.5
Methoxychlor 5%, resin 1%, sulfoxide 2%	11	0.7[2]	12	0.6	12	1.3[2]	17[1]	0.4	13	0.4
Dilan 2%, lindane 2%	17[1]	−1.0[3]	10	0.2	10	−0.2[3]	13	0.3	13	−0.4[3]
Methoxychlor 2%, dilan 2%	15	−0.3	20[1]	0.8	11	0.9	14	0.6	15	0.3
Check		0.1		0.5		0.4		0.6		0.6
Least significant difference (L.S.D.)		0.6		0.6		0.5		0.3		0.7

[1] Significantly different from check.
[2] Significantly better than check.
[3] Significantly poorer than check.
The triangular values indicate the number of correct selections out of 30, with at least 16 required for significance.
The multiple comparison values represent average scores with positive values indicating acceptable flavor, and negative values indicating off-flavor.

might therefore be concluded at this point that the variables method was several times more efficient than the attributes method, as could have been predicted by theoretical statistical considerations.

A further examination of the data in Table 4 reveals the worrisome fact that in only three cases do both methods point to the same conclusions; namely, that significant differences exist, although three additional significant points indicated by the attributes test were not confirmed by the variables test and, similarly, four significant points indicated by the variables test were not substantiated by the attributes test. These discrepancies emphasize the fact that absolute reliance cannot be placed on mere statistical significance—particularly if the results cluster about the 5% level of significance where an average of one out of twenty supposedly significant results may still be due to chance. Thus, in a screening operation involving a search for off-flavor involving substantial numbers of pesticides and products, the significant results—particularly those at the lower level of significance—should be reinvestigated before recommendations are issued concerning the effect of particular pesticide applications on the off-flavor of a particular crop.

Triangular taste tests per se provide no information on the nature of the significant difference, if any is obtained. Referring to the three results that were found to be significant by both methods, only the effect of dilan plus lindane on tomato juice may be said to point to a definite off-flavor, whereas the significant effects of methoxychlor on tomato juice and toxaphene on potatoes, are apparently due to an improvement in flavor, as indicated by the variables test. Similar results could probably have been obtained if in addition to a mere selection of the odd sample, the judges participating in the triangular taste panel were required to note whether the odd sample were better, poorer, or equal to the paired samples (or vice versa). Actually, such additional notations would change the original triangular attributes test to the simplest form of a variables test, where a 3-point scale is used. If this needs to be done, it appears to be more logical to utilize a variables design from the start rather than to patch a less efficient attributes method to provide the complete answer.

As stated previously, attributes methods appear to be most successful with products approaching homogeneity within lots. It is interesting that the most useful results (Table 4) from the triangular tests were on tomato juice, a fairly homogeneous material. In off-flavor studies, however, it is frequently impossible or at least impractical to obtain samples identical in all respects except for the insecticidal treatment. In such cases an attributes method like the triangular test becomes entirely inadequate. What is needed is an experimental design *(4)* by which variability resulting from other factors—location, maturity, etc.—may be determined and isolated from the variability caused by pesticidal treatments. Where a number of such factors are involved, an analysis from the range, as proposed above, may not be adequate, and the standard methods of computing the analysis of variance would be required.

These variables experiments may be designed to account for differences in time and order of presentation of individual samples for tasting, so that these factors, too, may be removed in order not to confound results obtained from the pesticidal treatments.

In the variables method proposed above, a 5-point scale is suggested, with positive values indicating acceptable flavor, and negative values indicating objectionable flavor. As stated earlier, it is not intended that a group of 5 to 15 judges, operating in a single locality, pass on the use of a pesticide solely on the basis of a single test. It is claimed, however, that such a variables analysis, when used as a first screening test will provide far more information with the expenditure of the same effort than an attributes method like the triangular taste test.

This problem of finding the most efficient taste testing design for specific purposes has been investigated only to a very limited extent *(2, 6)*. Much additional work is indicated—not only for the broad comparison of methods but also for answering such questions as: how much is to be gained by more elaborate training and selection of judges as compared to the use of a larger number of less well-trained judges? Or, to what extent can the time interval between successive testings be reduced, and additional tastings added within a fixed period of time?

SUMMARY

A simplified *variables* taste panel method for detecting flavor changes in vegetables treated with pesticides is presented. The method, based on the analysis of variance from the range eliminates a large part of the computations but nevertheless retains the greater part of the efficiency of a variables method. Results with five products indicate that this simplified variables method was superior to an attributes method such as the triangular taste test in detecting flavor differences. Moreover, it requires substantially fewer tastings, and at the same time provides additional information on the direction and importance of the differences.

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A Correlation Between the Heat Penetration and the Rate of Bacterial Growth During the Roasting of Turkeys[a]

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The roasting time of turkeys from both the frozen and thawed states were studied. The data indicate that the birds are in the optimum growth range for the Staphylococci and Salmonellae too short a time to permit extensive growth of the organisms.

The question of how much longer it takes to roast a frozen unstuffed turkey than a thawed turkey was raised. Therefore, heat penetration data for small (13 lb.) unstuffed turkeys, roasted at 350° F. from both the frozen and thawed states, were determined. These data were then correlated with the growth rates of the bacteria, *Staphylococcus aureus* and *Salmonella aertrycke*, as determined by other workers, to ascertain what happened to these microorganisms during the roasting process.

Bacterial growth manifests itself in a definite manner. According to Jensen *(5)*, bacterial growth is almost negligible under adverse conditions, and when microorganisms are transferred from an unfavorable to a favorable environment, cell reproduction does not occur for some time. Stumbo *(6)* and others concur with this observation. Stumbo calculated the lag phase to be the interval ab, whereas Jensen estimated it to be ac (see Figure 1). Toward the end of the lag phase, bacteria start multiplying at a low rate. Cell division then proceeds at a much higher rate as represented by a semilogarithmic relationship. This phase is represented by the straight line cd, which represents the logarithms of the numbers of bacteria per unit volume plotted against time. During this time, toxins and enzymes may appear *(5)*. After the logarithmic phase is completed, the bacteria continue to multiply at a low rate until a maximum is reached. The number is constant at the maximum for the time d to e (Figure 1). During this phase, because of depletion of essential nutrients and the accumulation of waste products, growth slackens until the rate of death equals the rate of multiplication. Thereafter, cell division ceases and the rate of death increases to a maximum. The phase of decrease in bacterial numbers is shown by the segment of the curve represented by ef.

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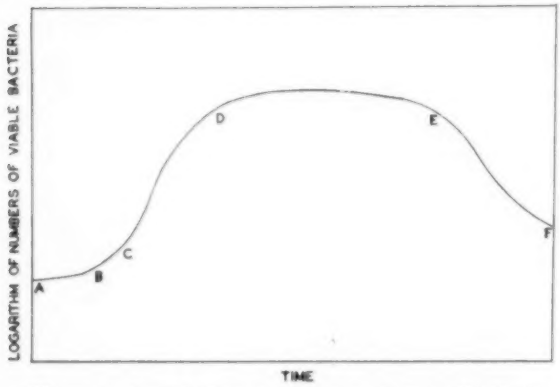

Figure 1. General form of the curve of the multiplication rates of bacteria.

According to Jensen *(5)*, "all of these phases are dependent, so far as time is concerned, upon the following conditions: size of inoculum, age of inoculum, frequency of transferring, stage of growth of inocula, nature of microorganisms, temperature, and nature of the medium." Jensen *(5)* and Stumbo *(6)* made use of this concept of bacterial behavior in predicting bacterial spoilage in food products during processing.

Jensen *(5)*, in calculating the process time for frankfurter tempering, determined the lag phases of *Staphylococcus aureus*, *Salmonella aertryke*, and other pathogens in frankfurter meat held at 84° F. for 6 hours. With this data Jensen showed that frankfurters may be tempered for 3 hours at 120° F. with safety as far as the sanitary aspects of the problem are concerned; bacterial growth did not proceed beyond the lag phase during such a tempering period. By applying this principle to turkey meat, it is possible to predict the extent of bacterial growth in turkeys due to the roasting process.

PROCEDURE

The rapidity of heat penetration into various parts of turkeys roasted from both the thawed and frozen states was determined. Two frozen, ready-to-cook turkeys were selected. One (12 lb. 7 oz.) was thawed at 38° F., and the other (13 lb. 12 oz.) was held in the frozen state. The packaged giblets were removed from the entrail cavities prior to roasting and no stuffing was used.

Thermocouples attached to a recording potentiometer were then inserted in the frozen and thawed turkeys at comparable points as shown in Table 1. Holes were drilled in the frozen turkey to permit insertion of the thermocouples. The points were selected on the basis that they should be located in regions of slowest heat penetration in an unstuffed turkey. The exact location of the thermocouple in each region selected was chosen by estimating the slowest heating point in that region. The turkeys were then roasted in a preheated oven at 350° F. until the temperature of the point of slowest heating reached the recommended removal temperature of 185° F.

Bacterial analyses of the turkey meat were not made. Therefore, in order to estimate the extent of bacterial growth during the roasting process, the data of Jensen *(5)* on the lag phase of *Staphylococcus aureus* and *Salmonella aertryeke*, cultured on frankfurter meat, were used. Even though the growth rates of these organisms on turkey meat would possibly differ from those on frankfurter meat, application of data in this manner with proper qualification is accepted practice in the food industry. Allowances were exaggerated on the side of safety in the calculation of the time-temperature relationships.

RESULTS AND DISCUSSION

Heat penetration data obtained from thermocouples VI and VIII were considered since they represent the points of slowest heating through the temperature range of 65-110° F., in the thawed and frozen birds, respectively.

For our purposes, it was assumed that *Staphylococcus aureus* had a 3-hour lag and *Salmonella aertryeke* a 4-hour lag when cultured in turkey meat at 84° F. It was assumed that the organisms had a 2-hour lag at 98° F. This assumption is based on the generalization that most mesophiles will exhibit a 2-hour lag at 98° F. when cultured in a suitable medium *(5)*.

The initial bacteria counts of the turkeys were considered large enough to reach toxic proportions upon activation.

Bacterial activation in turkeys will begin during the roasting process at 65° F. and continue until the temperature reaches 110° F. *(1)*. At 110° F. cell division ceases, although the bacteria are not necessarily destroyed. Temperatures above 120° F. are lethal to the *Staphylococci* and *Salmonellae (1)*. The number of viable organisms should begin to decrease at 110° F.

In problems of this nature consideration must be given to cumulative stimulating effect of heat at the continuously varying temperature to which the substrate is subjected during roasting. The net result in terms of

TABLE 1

Heat penetration data

Thermocouple number	Points in which thermocouples were placed	Depth of thermocouple in tissue	Time required to raise temperature to 65° F.	Time in growth temperature range of 65-110° F.	Time required to raise temperature to 185° F.
		Inches	*Minutes*	*Minutes*	*Minutes*
	Thawed roast				
I	Right breast	2	30	47	240
II	Left thigh	2½	30	47	216
IV	Right drumstick	2¼	30	47	207
V	Left rear breast	2½	36	36	197
VI	Posterior part of entrail cavity	2	120	60	249
	Frozen roast	1	47	103	300
VII	Right breast	1½	120	105	378
VIII	Left thigh	1	81	86	315
IX	Right drumstick	1¼	90	90	316
X	Left rear breast	½	90	90	Thermocouple removed, because it was recording oven temperature.
XI	Posterior part of entrail cavity				

growth lag time is at some intermediate point between the lag time at the lowest growth temperature and that at the optimum growth temperature. If the latter is less than the total period of time during which growth occurs, calculations must be made to determine whether or not the net lag time is less than the heating time during which the temperature of the substrate is within the range of bacterial growth. If the lag time at optimum growth temperature is not shorter than the heating time during which the temperature of the substrate is within the range of bacterial growth, no such calculations are necessary.

The thawed turkey increased in temperature from 65° to 110° F. in 60 minutes and the frozen turkey in 105 minutes. The minimum lag time assumed for the optimum growth temperature (98°) was 120 minutes. Thus, without the necessity of making a calculation, the conclusion was justified that, in both turkeys, the increase in the number of bacteria during roasting was insignificant since growth had been confined to the lag phase.

Thermal death times reported by Jensen *(5)* indicated that *Salmonella aertrycke* is completely destroyed in 23.8 minutes when heated in neutral broth at 131° F. or in 13.8 minutes at 140° F. In a similar medium, *Staphylococcus aureus* requires 18.8 minutes of heating at 149° F. to achieve the same effect.

The minimum lethal temperature for destruction of these organisms is 120° F. Calculations were made by the general method, modified by Ball *(2)*, to determine the time at which 100% sterilization was effected. The z (37.5) and F (0.015) values required for these calculations were found by plotting the thermal death times of the *Salmonellae* on semilogarithmic graph paper. However, in applying these data it had to be assumed that these organisms would exhibit the same thermal death times when turkey meat was the substrate.

The calculations indicated that sterilization of the frozen turkey (the slower-heating of the two birds) in respect to *Salmonellae* was complete at the end of 267 minutes of roasting. At this time the temperature at the point of slowest heating was 139° F. Therefore the *Salmonella* would not survive the roasting process. At the end of the roasting process, the amount of lethal heat which had been effective at the tested point in the turkey was equal to 66.5 times the amount theoretically required to destroy the *Salmonellae*.

An experimentally determined slope value of the thermal death time curve of *Staphylococcus aureus* was not available. If this slope value is the same as that indicated by Jensen's data for *Salmonella aertrycke*, calculations indicate that *Salmonellae* also would be destroyed during the roasting process. The sterilizing effect of the cooling period was not considered in these calculations.

Food poisoning ascribed to *Staphylococcus aureus* is due to the ingestion of high concentrations of this bacteria or its enterotoxin *(2, 5)*. According to Jensen *(5)*, "these organisms require 6 to 8 hours of steady growth (logarithmic phase) in a rich medium at 99° F. to produce enough toxin to elicit symptoms (vomiting and diarrhea) in man or monkey when food or broth is swallowed." Dack *(3)* showed that this toxin is somewhat stable toward heat. His experiments indicate that the enterotoxin was not completely destroyed after being heated at the boiling point of a beef infusion broth for 60 minutes.

The *Salmonellae* do not form toxins, but infect the intestinal tract directly *(5)*.

EVALUATION OF RESULTS

From these results, it is concluded that there is no apparent danger of food poisoning due to either *Salmonella* organisms or enterotoxin produced during the roasting period when unstuffed turkeys are roasted from the frozen state under the conditions specified in this study.

When the time-temperature relationships are compared, it is seen that the turkey roasted from the frozen state required more time to pass through the critical temperature range than the turkey roasted from the thawed state. However, the time differences are inconsequential since, in both cases, growth of *Salmonellae* was confined to the lag phase.

Even if growth had extended into the high rate phase, there would have been no hazard since evidence was provided by the theoretical analysis that neither the *Salmonellae*, the *Staphylococci*, nor the *Staphylococci* enterotoxin could survive the roasting process. To produce sufficient toxin to induce sickness in man, the *Staphylococci* require 6 to 8 hours of rapid growth. At no point, as shown in Table 1, did the frozen meat remain in the growing temperature range for longer than 105 minutes.

Food poisoning may be caused by the development of enterotoxin prior to freezing due to unsanitary plant conditions and practices, by the development of enterotoxin due to improper thawing at room temperature, or by poor handling of the finished roast.

Thus, the results of a theoretical analysis, based on principles which are of proven validity in evaluating canned foods processes, indicate that the roasting of non-stuffed turkey from the frozen state embodies no food poisoning hazard.

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New Test for Thermostabilized Eggs

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Two simple tests for thermostabilized eggs are reported. One test is based on measuring the alcohol number of the white; the other consists of determining the stability of the thermostabilized sample in a constant temperature water bath at 60° C.

Cotterill, Winter, Cook and Weiser of the Ohio State University in the development of a test for thermostabilized eggs *(3)* utilized the inactivation of enzymes by heat treatment or the so-called thermostabilization process of eggs, a method used extensively in certain areas of the United States *(2)*. The enzymes tested were lysozyme, phosphatase, and amylase. The results did not seem to be satisfactory, however, because the temperature applied to the thermostabilization treatment of eggs apparently is not high enough to bring about a complete inactivation of these enzymes in their natural environment inside the egg.

Another approach to this problem was made in our Laboratory by the study of possible changes occuring in the phosphates of the egg as a result of the heating during the thermostabilization treatment. Such changes were previously observed to occur in milk during pasteurization *(5)* and were shown to be due to a reaction between dicalcium phosphate and carbonic acid present there. These changes in milk were associated with a higher stability of phosphates in milk serum and thus were used for the development of a new test for heated milk *(6)*. Carbon dioxide gas coming from de-solution of free CO_2 from the ovalbumin of the egg is constantly liberated during egg storage *(1)*. New-layed eggs tested in our laboratory gave 1.56 mlg. CO_2/hour per 100 g. whereas stored eggs a few days old, gave 0.29 mlg./hr. per 100 g. Phosphates in significant quantities are present not only inside the egg but also in the shell *(8)*. The two cases therefore look more or less similar.

In our experiment fresh eggs from the poultry department of the Louisiana State University and stored eggs were thermostabilized in Moriol mineral oil by heating in a constant temperature bath at 54° C. for 8 minutes. The egg content was homogenized, diluted with equal amounts of water, and the proteins separated after precipitation by various processes. Among the methods used for the precipitation of the proteins of the eggs were (a) the addition of freshly prepared 1% tannic acid solution, and (b) the addition of 95% ethyl alcohol. The second method gave the better results, producing a very clear filtrate. Testing with ammonium sulfate gave no evidence that ovomucin was present in the filtrate.

Another method tried on the egg yolk was to freeze it at low temperatures to render the protein insoluble and then to mix it with water in the Waring blender and filter. The titration curves of the filtrates with all the above methods were studied; all of them showed a constant increase of monocalcium phosphate in the thermostabilized eggs (Table 1). The monocalcium phosphate in this case does not seem to derive from the dicalcium phosphate, as in the case of heated milk, but

TABLE 1

Showing changes in dicalcium and monocalcium phosphates in the whole egg content after thermostabilization.

Treatment	Buffering values after protein precipitation		Refractometer reading of filtrate
	Range from original pH to pH 4.4 (Dicalcium phosphate)	Range between pH 4.4-3.1 (Monocalcium phosphate)	
Untreated	0.00047	0.00074	
1) Thermostabilized	0.00048	0.00082	
Untreated	0.00027	0.00064	
2) Thermostabilized	0.00039	0.00080	
Untreated	0.00035	0.00057	
3) Thermostabilized	0.00050	0.00059	
Untreated	0.00037	0.00062	
4) Thermostabilized	0.00045	0.00071	
Untreated	0.00040	0.00066	
5) Thermostabilized	0.00046	0.00074	
Untreated	0.00036	0.00052	14.0
6) Thermostabilized	0.00043	0.00055	16.2
Untreated	0.00032	0.00057	14.5
7) Thermostabilized	0.00036	0.00059	15.0
Untreated	0.00034	0.00060	15.4
8) Thermostabilized	0.00045	0.00065	16.8
Untreated	0.00035	0.00061	15.5
9) Thermostabilized	0.00044	0.00068	16.7
Untreated	0.00038	0.00051	14.0
10) Thermostabilized	0.00042	0.00058	16.1
Untreated	0.00033	0.00062	
11) Thermostabilized	0.00041	0.00074	

*The titration is performed as follows: To 25 ml. of homogenized whole egg 25 ml. of dist. water is added and the mixture is brought to 100 ml. with 95% alcohol and filtered. The filtrate which is about 40-45 ml. when filtering is completed is made to 50 ml. with water and titration is carried out on a 20 ml. aliquot. The values are expressed in gram equivalents per 100 ml. of pure egg content.

rather from the tricalcium phosphate of the shell. Since tricalcium phosphate is present in considerable amount in the egg shell as well as carbon dioxide and water vapor inside the egg in close contact with the shell, it seems probable that the tricalcium phosphate reacts with carbonic acid to produce both dicalcium and monocalcium phosphate according to the following scheme:

$$(1)\ Ca_3PO_4 + CO_2 + H_2O \longrightarrow CaCO_3 + 2\,CaHPO_4$$

$$(2)\ Ca_3(PO_4)_2 + 2\,CO_2 + 2\,H_2O \longrightarrow 2\,CaCO_3 + CaH_4(PO_4)_2$$

That such a reaction can take place when a mixture of water vapor and carbon dioxide is passed over heated calcium phosphate was shown by Seybold and Heeder *(7)*.

Although the alcohol precipitation of egg proteins seemed complete and no protein interference could occur during the titration, a further investigation was made by titrating directly egg white dispersion in water at the pH range between 4.3 and 3.1 where no interference of ovalbumin occurs *(4)*. The results always showed a constant increase of monocalcium phosphate in the thermostabilized eggs (Table 2). Determination of calcium carbonate in the supernatant liquid of the filtrates after precipitation occurred by heating at

TABLE 2

Showing changes in monocalcium phosphate, alcohol number and stability to heat of egg white, due to thermostabilization.

Treatment	*Buffering values white suspension between pH 4.3-3.1	Alcohol number (ml. of alcohol per 5 ml. of egg white solution)	Stability to heat at 60° C.
Untreated	0.0032	3.0	normal
1) Thermostabilized	0.0042	1.5	weakened
Untreated	0.0035	3.5	normal
2) Thermostabilized	0.0034	2.0	weakened
Untreated	0.0038	3.9	normal
3) Thermostabilized	0.0041	2.3	weakened
Untreated	0.0036	4.0	normal
4) Thermostabilized	0.0039	2.5	weakened
Untreated	0.0038	3.0	normal
5) Thermostabilized	0.0052	1.6	weakened
Untreated	0.0032	3.4	normal
6) Thermostabilized	0.0039	1.8	weakened
Untreated	0.0033	3.5	normal
7) Thermostabilized	0.0042	2.1	weakened
Untreated	0.0046	4.0	normal
8) Thermostabilized	0.0048	2.2	weakened
Untreated	0.0035	4.0	normal
9) Thermostabilized	0.0042	1.5	weakened
Untreated	0.0045	3.5	normal
10) Thermostabilized	0.0047	2.0	weakened

*NOTE: Ten ml. of homogenized white are mixed with water and made to 100 ml. The titration is carried out on 50 ml. aliquot using $\frac{N}{10}$ HCL. Values are expressed in gram equivalents for 100 ml. of pure white.

70° C. showed an increase of calcium carbonate in the thermostabilized eggs—which adds further support to the foregoing theory for the reaction which takes place during thermostabilization.

Besides the reaction of the phosphates of the eggs, the results of which are varied due to the large variations in the thickness of the shell, the size of the egg, etc., certain other changes take place in the white and the yolk during the heating process. The measurement of these changes can be used as a definite test for thermostabilized eggs. The most apparent of these changes occurs in the white and is especially apparent in the degree of hydration of the ovalbumin particles.

The simplest approach is by determining the alcohol number of the solution. The test as it was developed with the egg whites is as follows: Ten milliliters of homogenized white are diluted (1:3) with water and filtered. To 5 ml. of the filtrate, whose pH runs around 8.5, alcohol (95%) is added at room temperature (25° C.) to bring flocculation in the solution. The number of milliliters of alcohol needed to bring about this effect is the alcohol number of the solution. A number of untreated and thermostabilized eggs which were stored for different lengths of time were examined and the alcohol number of their white was determined. The values obtained from untreated eggs were around 3.5 with maximum variation from 3.0 to 4.0. The alcohol number of the thermostabilized egg white was around 1.9 with a variation from 1.5 to 2.5. Figure 1 shows solutions of whites of thermostabilized and untreated egg after the addition to each of 2 ml. of alcohol.

Another quick test is to heat test tubes containing the diluted (1:3) and filtered solution of egg white in a constant temperature water bath at 60° C. The thermostabilized sample turns rapidly cloudy and later becomes opaque and of a milky white color; the untreated egg white remains limpid for a longer time and when

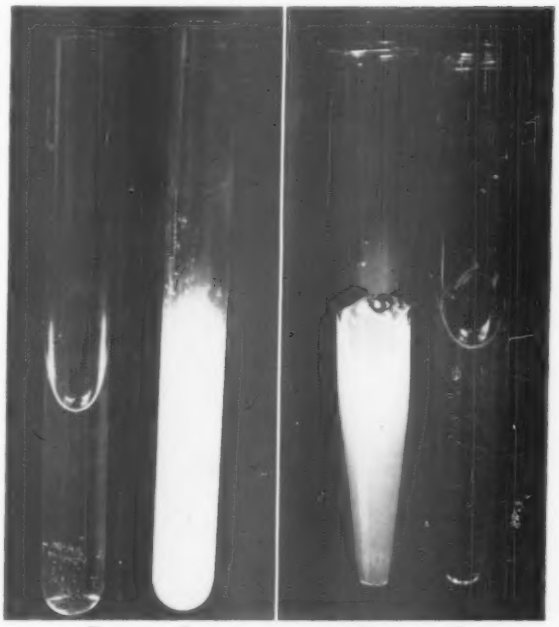

Figure 1. Comparison of untreated (U) with thermostabilized (T) egg white after addition of 2 ml. of alcohol.

Figure 2. Thermostabilized (T) compared with untreated (U) egg white after immersion in water bath at 60° C.

it becomes opaque has more of a bluish color than a milky white (Figure 2).

SUMMARY

The reaction between phosphates and carbonic acid previously studied on heated milk appears to occur also in thermostabilized eggs. The difference in hydration of the ovalbumin found in thermostabilized and untreated eggs resulted in the development of two simple tests for thermostabilized eggs by measuring the alcohol number of the white or its stability to heat.

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Notes and Letters

Comparison of Non-Treated and Fried Fresh and Frozen Beef As to the Drained Weight After Canning

The beef dish, Scotch collops, consists of fried pieces of beef ready-cooked in gravy. If frying is omitted, will the drained weight after canning be different compared to that of fried and canned beef, calculated on a fresh weight basis? This question is, among other things, of importance in labeling. Moreover, it is generally difficult to decide from appearance alone whether the canned meat has been fried or not.

Retention of solid meat after cooking of 600 g. pieces in water alone was found by Grau *(3)* to be 58½% for the better grades of beef and 52% for the poor ones; cooking in vapor gave a retention of about 55½ and 47%, respectively. Clark and van Duyne *(2)*, in their extended investigations on cooked pieces of rounds (5 lb.) got a 71% yield of weight after oven roasting and 64% after pressure saucepan cooking when heated to an internal temperature of 82° C. From the figures given by Bard and Tischer *(1)* it can be calculated that canning of fresh beef shoulders cut into cubes of 1-1½ inch and applying temperatures of 107° C., 116° C., and 124° C., will result in a constant value of the drained weight amounting to 65% of the fresh weight at all the temperatures mentioned, processing time for reaching this value being dependent on the temperature employed.

EXPERIMENTAL

The following scheme shows the experiments involved in the present study. Frozen beef is also included, since this material might behave in another way than does the fresh one. Further on, the influence of different methods of frying and packing the meat in the cans was studied.

A. Fresh Swedish beef

1. Pan fried	2. Machine fried	3. Non-treated,
a. Packed warm	a. Packed warm	packed
b. Packed cold	b. Packed cold	fresh

B. Frozen South American beef (thawed)

1. Pan fried	2. Machine fried	3. Non-treated,
a. Packed warm	a. Packed warm	packed
b. Packed cold	b. Packed cold	fresh

A material composed of lean parts of whole carcasses except loins and rounds and practically free from separable fatty and connective tissue was used. The meat was cut into pieces of 3-5 cm. The fresh Swedish beef was aged for 7 days and cut 15 hrs. before canning. The frozen South American beef (from Uruguay) was thawed and cut 15 hrs. before processing as well.

Frying was performed with the aid of lard. Pan frying required 20 min. for the Swedish beef and 26 min. for the South American. Loss of weight after pan frying varied between 31-34% (warm) and 34-36% (cold). The frying period in the machine was 4-5 min. (Swedish beef) and 5-6 min. (South American beef) at a temperature of 150-180° C. Losses of weight after machine frying was 25-26% (warm) and about 27% (cold).

Size of cans was 99/73 mm. (500 g.). The cans were packed with a quantity of meat corresponding to 400 g. of fresh beef. After filling with gravy sterilizing was accomplished in Hamar-Jern counter-pressure autoclaves for a period of 115 min. at 118-120° C.

The results are summarized in Table 1. Each experiment includes *six* cans.

TABLE 1

Experiment no.	Drained weight as a percentage of fresh beef		Experiment no.	Drained weight as a percentage of fresh beef	
	Average	Variance		Average	Variance
A 1a	58.7	0.34	B 1a	58.0	2.32
A 1b	61.2	3.12	B 1b	60.4	2.71
A 2a	63.0	6.06	B 2a	63.0	7.88
A 2b	59.5	8.19	B 2b	62.1	6.15
A 3	58.0	2.28	B 3	58.7	1.32
Grand mean	60.1	4.00	Grand mean	60.4	4.08

SUMMARY AND CONCLUSIONS

Canning pieces of fresh beef results in the same drained weight as does canning after previous pan frying and warm packing, calculated on a fresh weight basis. These methods yield the lowest retention of solid meat, about 58 to 59%. Machine frying combined with warm packing leaves the highest retention, on an average 63%, calculated in the same way. Applying the *F*-test, the sample variances, however, turn out to be too different to permit a calculation of possible significance as to the dissimilarity of the retentions. No significant difference of drained weight after canning exists with regard to the fresh and frozen beef used.

Olle Dahl
Scans Centrallaboratorium,
Malmö, Sweden

November 25, 1955.

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IFT REGIONAL SECTIONS . . .

(Continued from page 16 preceding technical papers

devotes itself at their research center at Wright-Patterson Air Base, Ohio, to pre-flight, in-flight and post-flight feeding problems with special attention to aircraft space-weight problems, to equipment for feeding aloft, and to unit meals (or snacks in some instances) for the airman just prior to flight or during flight. Figures 7 and 8 depict two constant concerns of

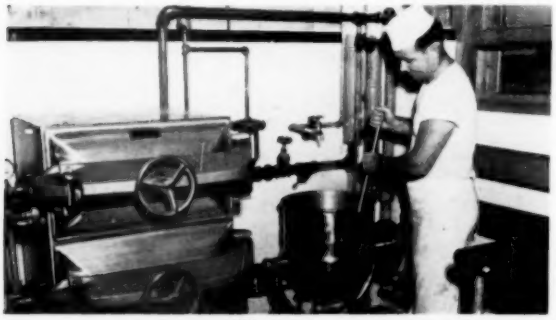

Figure 7

Figure 8

the Armed Forces—improving the ability to prepare food in cramped spaces and feeding men far removed from normal messing facilities.

Continuing the story of what we are doing today—we are at work bringing to ever greater effectiveness and wider application the technique of dehydration. We are also conducting a vigorous, but properly conservative and restrained program, to bring the peculiar advantages of radiation preservation into the military food supply pattern of tomorrow. Some progress has been made—for example, the very tangible achievement of extending the life of fresh produce.

It should be made clear that the radiation preservation program is a broad nation-wide effort, and that it is receiving great technical stimulus from many quarters—from our headquarters, the Command, at Natick, Massachusetts, from the Research and Development Office, OQMG, from the university and industry and other Governmental laboratories of the nation in addition to those of the Qm. F. and C. I. where the management of the program has been delegated. Great effort is being concentrated on the program. We do not say that a scientific "break through" is in sight, but the tempo of progress toward useful applications is definitely increasing.

A Look at Tomorrow. A few of the elements of tomorrow's food logistics are emerging. I speak from what is already in print. It is evident, for example, that ultramodern bombers in a future war will penetrate far inland and that defense will be regional in scope, requiring relatively self-sufficient, battalion-sized defense groups. The pattern of food supply will have to be adjusted to a swiftly moving, flexible kind of tactical defense that cannot be impeded by laborious food preparation and food service systems. Complete meals—possibly complete, precooked dehydrated meals, unit packaged—may be required. They will have to be brought, insofar as feasible, to the fighting man from food preparation stations remote from the scene of action. I can visualize a scene something like this (Figure 9)—a helicopter maneuvering for a landing,

Figure 9

and a hot meal coming up. Or rather down. These are some of the things I see, but the "world of tomorrow" is an inscrutable world, and it will take our best military thinking and our best industrial thinking to anticipate even its elements.

NEW YORK . . . .

Radiation Sterilization — Still in the Future. Preservation of foods by radiation sterilization has definite potential, although it will take time to work out the applications. Furthermore, once the technique is established, it will express itself to greatest advantage by complementing, rather than replacing, conventional processes such as refrigeration, dehydration, and heat.

These are the views of Dr. L. E. Clifcorn, Senior Research Associate, American Can Co., and National President of the Institute of Food Technologists. His talk on the present status and future role of radiation sterilization as a food-preservation method was enthusiastically received by a record turnout of 210 members and guests at the January 18 meeting of the New York Section of the Institute of Food Technologists.

(Continued on page 34)

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(Continued from page 32)

An extended version of Dr. Clifcorn's talk together with photographs will appear in FOOD TECHNOLOGY for April. The highlights of the talk follow.

Primary objective of present research, he said, is to overcome off-flavors, off-odors, and vitamin destruction in foods irradiated at levels required to preserve them. And the secondary task is toxicity studies.

The speaker outlined the mechanism of flavor protection by use of free-radical acceptors, such as ascorbic acid. They absorb OH groups which otherwise would produce off-flavors.

In discussing specific inactivation dosages (a measure of a food component's resistance to irradiation), it was noted that frozen foods withstand the process better than those treated in the fresh state. Another factor is the environment of a food component. For example, ascorbic acid and riboflavin are more stable in evaporated milk than in aqueous solution.

Limited toxicity testing of irradiated foods with human and animal subjects indicate no adverse effects. But much work remains since, as of October 1955, only 17 foods have been cleared for tasting. Similarly, there is need for much more acceptability data after storage tests.

Costwise, the process is expensive, but value added to a product may justify it. Also, the cost of radiation is bound to be reduced in time.

In predicting that radiation sterilization will be most effective when combined with other processes, Dr. Clifcorn cited results of recent research. They show that although Cl. botulinum is not reduced in its resistance to irradiation by pre-heating, an initial irradiation definitely lowers heat resistance of the organism.

In addition to his technical address, the speaker discussed affairs of the Institute. He told of plans to improve communication between regional sections and of activities directed toward interesting high-school seniors in careers in food technology.

PHILADELPHIA . . . .

Mrs. Corinne Robinson, Professor of Home Economics, Drexel Institute of Technology, presented a paper at a recent meeting of the Section on "Food Facts and Fallacies." The topic and facts presented were especially appropriate and well appreciated by the numerous lady guests. She stressed the importance of educating the consumer to buy and eat intelligently to partially overcome the increasing trend in foolish fads and fallacies that exist in this country. Mrs. Robinson stated that such fads were costing the consumer about $500,000,000 a year and all going into the pockets of "quacks." These "quacks," she pointed out, were at times so successful because they appeal usually to one's emotions; they relate half truths and invariably exaggerate the known facts. In addition, they are usually super-salesmen and in most cases have something to sell for which they realize great profits. To protect the public from these quacks she emphasized the need of publicizing authoritative information, more honest advertising and the scientists' responsibility to make the facts known to all the people.

GREAT LAKES . . . .

The Section held its Winter Meeting on January 27 at the Whittier Hotel, Detroit, Mich. The morning was devoted to a plant tour of The Continental Baking Company. The afternoon technical session heard the following papers:

"New Developments in Packaging"—James Goff, Professor of Forest Products, Michigan State University.

"Ascorbic Acid, A Versatile Food Adjunct"—Dr. C. M. Hollenbeck, in charge, Food Laboratory, Research Division, Merck and Co., Inc.

"Dairying"—Dr. Heber DePew, President, Sealtest Inc.

"Instrumentation in Food Processing"—Col. Paul Sherrick, Technical Director, E. H. Sargent & Company.

Dr. Lester E. Keuntzel of the Wyandotte Chemicals Corp. was the after-dinner speaker and his subject: "Infrared—The F. B. I. of Chemistry." Dr. Kuentzel is Head of the Physical Analytical Laboratories in the Company's Research and Development Division. His chief interests have been in instrument analysis in the fields of emission spectroscopy, infrared and ultraviolet absorption spectroscopy, x-ray diffraction and electron microscopy.

NORTHEAST . . . .

The fourth meeting of the current year of the Northeast Section was held at the Acorn Park Laboratories of Arthur D. Little, Inc.

An attendance of over 125 people were present for students' night honoring some 56 students of the Departments of Food Technology at the Massachusetts Institute of Technology and at the University of Massachusetts.

The Prescott Award was made by Dr. Jean F. Caul, Chairman of the Committee, to Mr. Philip S. Rane (M.I.T. 1954) who is now a medical student at Tufts Medical School, and a copy of the citation was given to the Department of Food Technology at the Massachusetts Institute of Technology.

In addition, announcement was made of the General Foods Fund Award to Mr. Harold M. Rich.

Mr. W. Leverett Cummings, Chairman of the section, then directed a few well chosen remarks to the students.

The feature speaker of the evening, our National President, Dr. L. E. Clifcorn, was then introduced by the Vice-Chairman, Dr. Samuel A. Goldblith.

Dr. Clifcorn presented a factual, realistic and thought provoking discussion of some of the problems of chemicals in Foods. Following this, Dr. Clifcorn spoke to the students about their future in Foods and pointed out that the National IFT recognized the problem of

(Continued on page 36)

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(Continued from page 34)

acquainting students at the secondary school level with the food industry and has prepared a new booklet for this purpose.

Attending the Students' Night meeting of Northeast were three past presidents and the current president of the National IFT. Standing, l. to r., Carl R. Fellers, Bernard E. Proctor, seated, Samuel C. Prescott and LaVerne E. Clifcorn, who made the major address of the meeting. (Photo by Spiegel.)

Dr. Clifcorn's presence was also enhanced by three past Presidents, Dr. Samuel C. Prescott, Dr. Bernard E. Proctor and Dr. Carl R. Fellers being in the audience.

The next meeting of the year will be held in honor of the 50th anniversary of the Wiley Act and the Guest speaker will be Mr. John L. Harvey, Deputy Commissioner of the Food and Drug Administration.

MARYLAND . . . .

The Section's January 13th dinner meeting was attended by thirty-five members who heard an interesting discussion on the uses of sorbitol.

The speaker, A. J. Stewart of the Atlas Powder Company, spoke on the applications of sorbitol in the food industry. This versatile material finds application in the beverage industry as a sweetener and "mouth filling" agent, supplementing the use of synthetic sweeteners as replacements for sugar. It finds similar application in the ice cream industry, where it is used, together with other synthetic sweeteners, to produce a lower calorie product without marked loss of texture and feel. It is in the candy industry, however, that it has become most popular. Its remarkable properties as a humectant permit the manufacture and distribution, on a commercial scale, of candy types which, in their ordinary form, would dry out and become unsalable before they could reach the consumer. The candy industry is the largest user. These properties of sorbitol also make it a useful ingredient in the baking industry. Following his talk, Mr. Stewart showed an interesting color film, prepared by the Atlas Powder Company, demonstrating methods for the manufacture of candy under commercial conditions, but on a laboratory or pilot scale.

A question and answer period served further to bring out the interesting and useful properties of sorbitol and its applications, particularly in the confection and beverage fields.

WESTERN NEW YORK . . . .

R. B. Barret, Technical Director, Klenzase Products Inc., Beloit, Wis., addressed the Section's January 23rd meeting held at the Erie County Technical Institute, Buffalo, N. Y. Mr. Barret discussed detergents, bactericides and their peculiar application to the problem of fats and oils. Following his address, he was queried on various aspects of sanitation practice.

DIXIE . . . .

The Dixie Section of the IFT has been studying the uniform food law for Georgia and the surrounding states. The topic was brought before the group when Thomas M. Christopher, Dean of Emory University Law School, discussed this subject at a regular meeting.

The interest was so keen that a committee was appointed to formulate a program by which Dixie Section IFT'ers can continue these studies. On the committee is Dr. C. R. Clark, retired State Food Inspector, J. J. McManus, retired Federal Food Inspector, A. S. Perry, Foods Consultant, L. J. Sweitfeger, Foods lawyer, and Dean T. M. Christopher.

The program for the present will be entirely educational, working through Civic Clubs, P. T. A., and other groups. After this has been accomplished the committee will likely become interested in improving food laws through legislation.

PERSONNEL

Dr. Emil Mrak, head, Food Technology Department of the University of California at Davis, has been invited to give a course of lectures in Switzerland during May and June of this year. Dr. Mrak's tentative plan lists lectures on the historical background of the U. S. food industries, the nature and scope of food technology as a profession, graduate training in this field, typical problems in food research and technology and their solution. The invitation was extended to Dr. Mrak by Dr. K. Durrenonett, Nestle Alimenta, Entre deux Villes, Vevey, Switzerland.

The Chicago Chapter, American Institute of Chemists, honored Dr. Roy C. Newton, Vice President in Charge of Research, Swift and Co., with an honorary membership at a banquet held on February 17, 1956, at the Chicago Engineers Club. Dr. Newton addressed the group on "Agricultural Research and Industrial Growth."

Food Research Laboratories, Inc. signalized the thirtieth anniversay of Dr. Bernard L. Oser's affiliation with their organization with a memento of the occasion, a bound book containing several hundred congratulatory messages from his friends and scientific associates in many parts of the world.

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FEATURING THIS MONTH . . .

New Perspectives on the Training of Food Technologists at the Massachusetts Institute of Technology*

Bernard E. Proctor
Department of Food Technology, Massachusetts Institute of Technology

A DECADE HAS PASSED since the formal establishment of the Department of Food Technology at the Massachusetts Institute of Technology (Cambridge, Mass.) on a par with the other formal departments at M. I. T. During this period over 100 degrees have been granted in the field of Food Technology, including 62 B.S. degrees, 24 S.M. degrees, 11 Ph.D. degrees and 6 Sc.D. degrees. In addition, over 100 special graduate students have been enrolled for periods varying from one to two years, some of whom were military officers detailed for special training in food technology.

Home of the Department of Food Technology, MIT

Approximately 1200 students are now majoring in the science departments at M. I. T., and of these, 5% are enrolled in food technology. In most fields of science it is increasingly difficult to consider a man adequately trained in his profession without a doctorate or the equivalent. Graduate study is, therefore, of outstanding importance. This year 40 students are registered for study toward advanced graduate degrees in Food Technology at M. I. T. The M. I. T. Department of Food Technology produces about 10% of the nation's food technologists and, as now organized, has ample facilities in the Dorrance Laboratories to handle an expansion of graduate students of about 50%, all of whom are needed in industry.

During the past two years, the faculty of the Department of Food Technology has been studying closely the curriculum at our institution in the light of the experience of the past decade and the current needs of modern food science and technology. As the fundamental philosophy of the training of food technologists at M. I. T., described earlier *(1)*, has not changed, it is quoted below as a reference for further discussion.

> "The fundamental philosophy relating to the training of food technologists at the Massachusetts Institute of Technology is to provide a basic curriculum that will enable the graduates to go into any food industry and utilize techniques or equipment of chemist, physicist, biologist, or engineer as need may demand. In contrast to courses of training designed to produce dairy technologists, cereal technologists, or specialists concerned with other individual types of food commodities, the food technology curriculum at the Massachusetts Institute of Technology has consistently placed emphasis on a broader training through basic science, thus to produce men skilled in the fundamental principles of the instruments and the methods by which any kind of food can be analyzed, modified, combined with other foods, processed, or controlled. The objective of such training has been to make the graduate more versatile and of greater value to himself and his future employers."

It is our belief that the major educational institutions in the United States interested in the teaching of food technology should devote their efforts to providing their students with a sufficient background of fundamental knowledge in the sciences to become key men in the food industries of the future.

A clear distinction should be made between *food technologists* with four or more years of scientific training and food technicians who are much less extensively trained. The food technologist and the food technician are not the same. The technician is able to carry out certain routine tests or procedures for which he has been specially trained. The technologist should be able to apply basic principles and knowledge in order to interpret, evaluate, and utilize the results of routine tests in a broader and deeper consideration of the prob-

(Continued on page 40)

Seminar Coke Break

* Contribution No. 283 from the Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Massachusetts.

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American Cancer Society

(Continued from page 38)

lems demanding his skill and attention. M. I. T. trains only food technologists, as defined above.

It would be unreasonable to expect any student, in a college training period of only 4 years, to attain a complete scientific background and outstanding skill in all fields pertinent to food technology. However, at the completion of his college training in food technology, the graduate should have acquired basic knowledge enabling future rapid development of specialized skills and acquisition of professional experience.

Object of the food technology curriculum at the Massachusetts Institute of Technology is to use the four undergraduate years to implant and develop in the student a broad understanding of the fundamental sciences and engineering principles utilized in food technology, and to focus the efforts of the student on the interrelations and the applications of these fundamental sciences and engineering principles in a wide and generalized field of food processing, with less regard to the specialized steps or processes.

Curricula. Old and new curricula are given in Tables 1 and 2. The following important changes may be noted:

First Year. No longer are Engineering Drawing and Descriptive Geometry compulsory courses. This is not merely a departmental edict but a curricular change approved by the entire M. I. T. faculty and applied in all science and engineering departments. In place of the two so-called "graphic" courses cited above, all freshmen are now required to take one course designated as a freshman elective (Table 2). This course may be taken in either semester or, if the student so desires, one elective may be taken in each semester. The Engineering Departments at M. I. T. (Mechanical, Electrical, Chemical) recommend that freshmen therein enroll in one graphics course.

TABLE 1
Undergraduate Courses in Food Technology, Massachusetts Institute of Technology, as of 1950

First Term	*Second Term*
FIRST YEAR	
Chemistry, General	Descriptive Geometry
Physics	Calculus
Engineering Drawing	Military Science
English Composition	Athletic Program
Quiz Hour (calculus, chemistry, physics)	
SECOND YEAR	
Qualitative Analysis	Calculus
Quantitative Analysis	Differential Equations
General Biology	History—Humanities
Physics	Military Science
REQUIRED DURING SUMMER	
Organic Chemistry	Organic Preparations
THIRD YEAR	
Physical Chemistry	Technology and Chemistry of Food Supplies
Physical Chem. Laboratory	Industrial Microbiology
Colloidal Chemistry	Bacteriology
Introduction to Business Management	Economic Principles—Humanities
Elective Subjects	
FOURTH YEAR	
Food Engineering	Technology of Food Products
Biochemistry	Chemical Engineering Food Applications
Chemistry of Nutrition	Thesis[1]
Humanities	

[1] The thesis involves more than 200 hours of study and original investigation with respect to some phase of food production and research.

TABLE 2
Undergraduate Courses in Food Technology, Massachusetts Institute of Technology, as of 1955

First Term	*Second Term*
FIRST YEAR	
First and Second Terms	
Chemistry, General	Calculus
Physics	Military Science
Western Civilization, Found.	Elective Subject
SECOND YEAR	
General Biology I	Quantitative Analysis
General Biology Lab. I	Physics
Physics	Bacteriology
Food Production	Humanities
Humanities	Prob. and Operations Anal.
Calculus	Military Science
Military Science	
THIRD YEAR	
Organic Chemistry I	Instrument. Analysis
Physical Chemistry I	Instrument. Anal. Chem. Lab.
Chem. and Tech. Food Sup. I	Physical Chemistry II
Industrial Microbiology	Chem. and Tech. Food Sup. II
Humanities	Humanities
Elective Subject	Elective Subject
FOURTH YEAR	
Food Engineering	Food Engineering
Gen. Biochem. and Physiol. I	Tech. of Food Products
Tech. of Food Products	Chem. Eng. Food App.
Chem. Eng. Food App.	Thesis
Chemistry of Nutrition	Humanities
Thesis	Elective Subject
Humanities	

Second Year. Qualitative chemical analysis has been replaced by a later course in Instrumental Chemical Analysis in the third year. A second semester of General Biology has been replaced by a new course entitled Food Production (offered by the entire departmental faculty), presented in the first semester. This Food Production course is actually a broadly planned composite of plant botany and animal biology, descriptive of economic crop plants and animals used as food sources. It is the departmental student's first contact with Food Technology and consists of lectures, elementary laboratory exercises, field trips, and motion pictures. In addition, Bacteriology has been moved into the second semester of the sophomore year. A change has also been made in the mathematics courses. Following 3 semesters of Calculus, one semester of Differential Equations has been replaced by a new course called "Probability and Operations Analysis." This new course includes the study of linear differential equations with constant coefficient, gamma and beta functions, and probability. Mathematical theory and techniques particularly appropriate to application of the scientific method to solution of business and industrial problems are included.

Third Year. In the third year, Physical Chemistry is no longer an optional subject but is compulsory for two semesters. There is opportunity for two elective subjects in addition to the courses listed in Table 1, and Organic Chemistry Laboratory, Advanced Mathematics, and Statistical Theory are highly recommended to the students as elective courses. Some students take their senior year courses in the humanities (eight of these courses are required and ten may be taken for the S.B. degree) during the junior elective hours and take graduate departmental courses such as Advanced Food Technology or Food Applications of Ionizing Radiations in their senior year.

Another important change in the junior year has been the initiation of a new course in Instrumental Chemical Analysis, supplemented by a course in Instrumental Analysis Laboratory. This has been made possible by omitting Qualitative Analysis in the second year and moving up Bacteriology and Industrial Microbiology. These new courses in Instrumental Analysis are

(Continued on page 42)

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(Continued from page 40)

invaluable to the modern food technologist, because they enable him to understand and use the mathematical and theoretical bases necessary for the functioning of modern optical and electrical instruments in the solution of chemical problems. These courses are supplemented by well-coordinated laboratory work wherein the students become familiar with the use and construction of equipments applicable in polarography, potentiometry, conductometry, thermal conductometry, R. F. conductometry, nephelometry, fluorometry, flame photometry, automatic instruments, and ultraviolet, infrared, and visible spectrophotometry.

Fourth Year. No changes have been made in the courses for the fourth year other than re-emphasis on engineering applications to foods and the thesis requirements, the value of which is shown in the increasing number of S.B. theses that are being published each year.

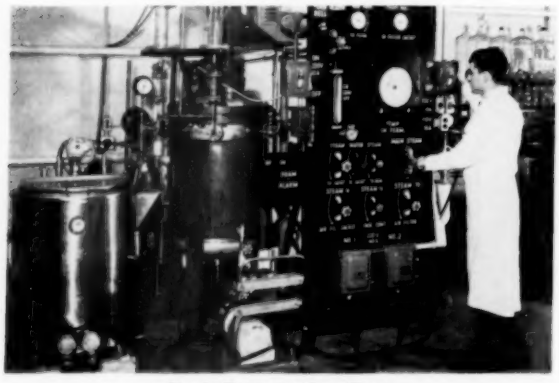
Five Year Curriculum. In addition, the Department of Food Technology offers high-ranking students training leading to a combined S.B.-S.M. degree in 5 years. The requirements for the last two of these years are shown in Table 3. Between the fourth and the fifth year, a period of approximately six months may be spent in industry.

TABLE 3
Requirements for Fourth and Fifth Years in Five-Year Curriculum as of 1955
(Same as shown in Table 2 through Third Year)

First Term	*Second Term*
FOURTH YEAR	
Food Engineering	Food Engineering
Gen. Biochem. and Physiol. I	Tech. of Food Products
Tech. of Food Products	Chem. Eng. Food App.
Chem. Eng. Food App.	Chem. of Nutrition Lab.
Chemistry of Nutrition	Humanities
Humanities	Elective Subject
GRADUATE YEAR	
Enzymology	Food Technology, Adv.
Food Technology, Adv.	Food Technology Seminar
Food Technology Seminar	Thesis
Thesis	Elective Subjects
Elective Subject	

Biochemical Engineering. The Department also has responsibility for training students in the field of Biochemical Engineering and awards degrees in this subject. This coordinated program, designed to train men in the production of pharmaceuticals such as antibiotics and in the fermentation industries, is presented in Table 4.

Doctorate. Further graduate study for the doctorate in Food Technology is, as before, optional with the individual. However, every graduate student in Food Technology, whether a candidate for an S.M. or a Ph.D. degree, must take the



Food Fermentation Tests

TABLE 4
Program in Biochemical Engineering, 1955
(Same as shown in Table 2 through Second Year)

First Term	*Second Term*
THIRD YEAR	
Organic Chemistry I	Instrument. Anal. Lab.
Organic Preparations I	Organic Chemistry II
Physical Chemistry I	Qual. Organic Analysis
Physical Chem. Lab. I	Physical Chemistry II
Industrial Chemistry	Physical Chem. Lab. II
Industrial Microbiology	Humanities
Humanities	Elective Subject
Instrument. Analysis	
FOURTH YEAR	
Gen. Biochem. & Physiol. I.	Chem. Eng. Food App.
Chem. Eng. Food App.	Biochemical Eng.
Chemistry of Nutrition	Thesis
Biochemical Eng.	Humanities
Thesis	Elective Subjects
Humanities	

courses in basic disciplines (or have had the equivalents elsewhere) listed in Table 2.

Graduate Elective Courses. Enlargement of staff and increased facilities have resulted in an increasing number of graduate elective courses that students may take. These include two electives in Food Applications of Ionizing Radiations (now being offered for the sixth successive year), a course in the Technology of Lipids, a course in Advanced Food Bacteriology,

Studying Food Irradiation Phenomena

two courses in Advanced Food Technology, Advanced Nutrition, and a Food Industries Seminar in which distinguished leaders in the food industry (food research, administration, management, production, and equipment) are invited to participate. This seminar has proved to be extremely valuable.

Summer Refresher Course. Since 1949, the Department has offered a brief refresher course in Food Technology given by the entire departmental faculty during the summer session and generally of three weeks' duration. This course has usually attracted over forty persons each year, from all facets of food science and technology. In the past two years, students have been offered the opportunity to select, in the third week, one of five possible electives, i.e., Sanitation and Bacteriology, Flavor Evaluation and Food Acceptance, Food Engineering, Food Application of Ionizing Radiations, and Nutrition. This course has served as an excellent means of cementing contacts with the food

industries and has been a challenge in post-graduate teaching.

Conclusions. The arrangement of food technology courses on a broad scientific basis has been the foundation of the Department's curriculum since its inception and several other educational institutions have initiated programs with similar objectives.

The rapid developments in science and the anticipated future applications contributing technical progress in the food industry must keep pace. Although the program here described for 1955 may require as extensive changes five years hence as the changes described in 1950, which have now been modified, such changes represent progress in the present and a challenge for the future.

The rate of change in the food industries, generally called "progress," has stepped up radically in the past decade. With these changes those who train food technologists must keep their graduates attuned to the frontiers of food science and techniques.

The duties of graduates in the field of food technology are bound to increase, both in number and scope, as all estimates indicate a tremendous increase in the needed production of manufactured foods in the future. It has been predicted that for every four hungry Americans sitting down to a meal today there will be a fifth person to feed in 1975. To grow and process the needed increased food supplies, there must be a great increase in the number of trained food technologists in the near future. Our new freshman elective "Man's Food" for all M. I. T. students, is proposed to inform other students of this need.

It is hoped that the Food Technology curriculum outlined above will result in attracting more and better men to the field of Food Technology and the service of the food industries.

LITERATURE CITED

1. Proctor, B. E. The training of food technologists at the Massachusetts Institute of Technology. *Food Technol.*, 4, 303 (1950).

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FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1956

March 13-14	Fourth Annual Dairy Engineering Conference, Kellogg Center, Michigan State University, East Lansing, Michigan
March 15-16	First International Symposium on Physics in the Food Industry Plaza Hotel, San Antonio, Texas
March 16-17	**Fourth Annual Food Technology Short Course for 1956, Campus of the University of Missouri, Memorial Student Union, Columbia, Missouri**
April 8-13	One hundred and twenty-ninth National Meeting of the American Chemical Society, Dallas, Texas
April 11-13	Annual Meeting of the Research and Development Associates, Food and Container Institute Inc., Hotel Statler, Boston, Mass.
April 16	Second Conference on Problems of Extraneous Matter in Foods Department of Plant Sciences, Syracuse University, Syracuse, New York
April 23-25	Forty-seventh Annual Spring Meeting of the American Oil Chemists' Society, Houston, Texas
June 6-9	**Sixth Annual Convention of the Australian Sections of IFT, Ritz, Leura, N. S. W., Australia**
June 10-14	**Sixteenth Annual Meeting of the Institute of Food Technologists, Hotel Jefferson, St. Louis, Missouri**
June 10-14	Seventy-third Annual National Confectioners' Association Convention, Boston, Massachusetts
June 18-22	International Congress on Food Distribution, Rome, Italy

FOOD INDUSTRY TOPICS...

. . . by Norb Leinen

. . . in the public interest

By 1976, the U. S., needing to produce $750 billion annually in goods and services, could find it is 76 billion man-hours short of filling this production goal, according to the Du Pont employee magazine, *Better Living*. Only by automation and similar technological improvements can the nation hope to avoid this dangerous labor shortage, the magazine said in its January-February issue. Pointing out that technological innovations now enable the typical industrial employee to turn out about 85% more work than in 1936 with far less physical effort, the article traces the dual rise of technological improvements and population in the nation, and comments: "If the past is any guide to the future, there is every reason to believe the nation will find ways and means to fill the demand of its people in 1976, for the history of the past 175 years is the virtually unbroken story of an expanding population matched and exceeded by expanding output."

◆ ◆ ◆

Sterilization of foods by nuclear radiation isn't just around the corner, according to Dr. Leonard Reiffel, supervisor of nuclear physics at Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago 16, Ill. What does seem possible, according to Dr. Reiffel, is radiation pasteurization — killing most, but not all, the bacteria. This requires much less radiation, does not destroy food quality, and still lengthens storage life under refrigeration. Radiation retarded spoilage will present fewer shipping problems, provide a supply of seasonal foods throughout the year, and enable greater utilization of surplus foods. "This is possible right now with present knowledge," Dr. Reiffel said, "and 1956 should see actual trials of the method for some products, at least."

News of a $5 million building program which will give Armour Research Foundation of Illinois Institute of Technology one of the most complete industrial research centers in the world also was received. The program calls for construction of three buildings and substantial additions to two buildings over the next ten years—based on the assumption that the Foundation will have a research volume of $16 million and a staff of 1,600 by 1961.

◆ ◆ ◆

How dangerous are household chemicals and agricultural poisons to the general public? This complex question was covered by six experts in a panel discussion presented before the section on pharmacy at the 122nd meeting of the AAAS on December 29. The discussion was sponsored by two committees of the American Medical Association—the new Committee on Toxicology and the Committee on Pesticides. Mr. Bernard E. Conley, secretary of the two AMA committees, who served as moderator, pointed out that the many new chemicals, responsible for making our daily lives more comfortable, complicate the health picture, and consequently must be handled with care and

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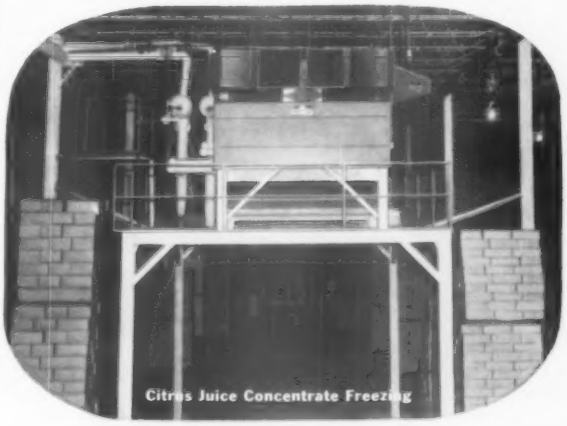

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understanding. In summing up the consensus of the meeting, Mr. Conley said top priority in accident prevention programs should be given to: (1) increasing safety awareness of laymen; (2) wider use of precautionary labeling on products; and (3) more accuracy in death certificates and hospital records through proper identification of the poisonous agents.

The Committee on Pesticides announces availability of free reprints of its two latest reports entitled, "The Present Status of Chlordane" and "Fatal Chlordane Poisoning." Write American Medical Assn., 535 N. Dearborn St., Chicago 10, Ill.

◆ ◆ ◆

The Association of Official Agricultural Chemists recently announced appointment of 23 chemists to test proposed methods and develop new methods of analysis for pesticide residues on foods. All chemists named to head the individual studies are employed by the Food and Drug Administration in its district laboratories or in its research laboratories in Washington, D. C. The appointments were made to aid enforcement of the Miller Amendment to the Federal Food, Drug, and Cosmetic Act. This amendment requires FDA to set safe tolerances for the amounts of poisonous pesticides which may remain as residues on food. An invitation was extended to interested chemists to assist in these studies. Those who would like to submit methods or participate in the collaborative work are invited to contact Mr. Wm. Horwitz, secretary, Association of Official Agricultural Chemists, P. O. Box 540, Benjamin Franklin Station, Washington 4, D. C.

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Today's $16 billion restaurant industry, an increasingly attractive market for food and equipment manufacturers, will use new methods of promotion, new equipment, and new pre-portioned and pre-prepared food products to overcome increasing overhead and labor costs. By 1975, while population increases 35%, eating away from home will increase 125%, to an annual volume of $35 million. The forecast, made by Mr. Leo Nejelski, president of the management counseling firm of Nejelski & Co., 12 E. 41st St., New York City, and executive vice president of the Institutional Food Manufacturers of America, in a recent article in *Restaurant Management* magazine, is based on studies his firm has conducted for a number of clients. The major problems of today—increasing overhead and labor costs—will be met, he says, by using new techniques and products developed by food manufacturers to reduce kitchen costs, such as pre-prepared and -portioned foods, and by increasing sales volume. He foresees the cost factors and others creating fewer small restaurants and more large units and chains, and predicts an increase in food manufacturers' advertising in cooperation with the National Restaurant Association's "eating out" promotion. However, he believes that "the restaurant industry is sorely in need of some basic studies on the motivations for eating out."

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An expended research program to develop superior varieties of sugarcane and sugarbeets with greater resistance to disease, cold, insects, and nematodes, and more suitable for mechanized operations has been recommended by the USDA's Sugar Research and Marketing Advisory Committee. The committee also urged accelerated studies to complete the inventory of chemical constituents of sugarcane and sugarcane juice and their relations to processing behavior and yield. Such work, it was pointed out, is fundamental to effective production and utilization research. In marketing research, the committee gave high priority to determining the feasibility and value of developing grades and standards for feed molasses which would indicate to the feed trade the purity and sugar and protein values of this product.

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The Milk Carton Quality Preforming Council has been formed by a group of manufacturers of preformed cartons to maintain a quality control program in this field, and to act as a clearing house for dissemination of new ideas and methods. Meetings will be held semi-annually, at which time technical problems pertaining to paperboard, carton forming, carton filling, testing, labeling, storage, bacteriological sampling, etc., are to be discussed. Membership is open to all segments of the industry interested in milk carton preforming and filling. Address Mr. Harold Wainess, Council secretary, at 228 N. LaSalle St., Chicago 1, Ill.

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Spread-type foods in collapsible metal tubes may appear in greater numbers in 1956, Mr. Lester B. Platt, executive secretary of the Collapsible Tube Manufacturers Council, stated. He pointed out that laboratory testing of preserves, jellies, peanut butter, mustard, catsup, mayonnaise, cake icings, fish and meat pastes, and cheese spreads is now at its highest point. This interest, he said, extends also to the Armed Forces who are experimenting with concentrated foods that can be packaged in lightweight, durable containers able to withstand any extremes of temperature. The 16 firms producing collapsible metal tubes had their biggest year in 1955, with shipments exceeding one billion units for the first time.

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"A warm thank you to the American people" was the theme of the Tenth Anniversary, January 18, of the founding of CARE, the organization which has brought person-to-person aid to individuals in 54 countries. In meetings in January, members of CARE's planning and executive staffs from national and regional offices heard reports of the chiefs of field missions, and discussed future self-help programs and the more effective use of surplus foods. CARE's address is 1028 Connecticut Ave., N.W., Washington 6, D. C.

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Trustees of The General Foods Fund, Inc., an independent foundation sponsored by General Foods Corp., announced in December grants totaling $278,000 in the foundation's aid-to-education program for 1955. Three colleges—Amherst, Hamilton, and Oberlin—were selected to receive grants of $25,000 each. Grants totaling $117,500 were made to 16 state and

regional associations of private liberal arts colleges. Grants also were made to three foundations: $25,000 to the National Fund for Medical Education, $20,000 to the United Negro College Fund, and $2,500 to the Future Scientists of America Foundation of the National Science Teachers Assn. Five four-year scholarships in the field of the physical sciences, to be administered by the National Merit Scholarship Corp., and two graduate-study fellowships in food technology to be administered by the IFT complete the program.

. . . *things new under the sun*

American Can Company announces development of **three new closing machines,** one with a record capacity of up to 1,000 cans per minute, to meet the present high-speed requirements of carbonated beverage canners. The Canco 212-8RG, the ultra-high-speed 1,000 C.P.M. machine, is a self-contained can-resolve closing machine for double-seaming round cans, and is equipped with eight seaming units mounted in a revolving cage. It will close cans ranging from 202 to 211 in diameter and from 211 to 604 in height. The Canco 410-4RG, with four seaming units mounted in a revolving cage, closes up to 350 cans per minute in sizes from 202 to 404 in diameter and from 2¾″ to 7½″ in height. The 411-6R2-G will close cans up to 550 per minute, and is equipped with six seaming units mounted in a revolving cage. It handles cans ranging in diameter from 202 to 404, and in height from 214 to 708. For information, write Carl Byoir & Associates, Inc., 10 E. 40th St., New York 16, N. Y.

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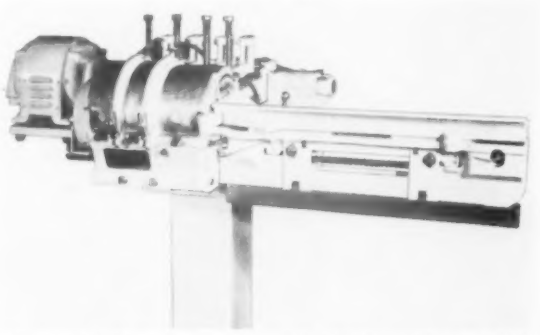

Increased yields, uniform cutting, and reduced operating cost highlight advantages of the new FMC Model 3A Universal Corn Cutter. Designed with new concepts of automation, the Model 3A employs an automatic size detection system that pre-opens cutting knives to size of ears regardless of varying ear diameters, eliminating size grading of ears and painstaking manual adjustment of knives. Constant pressure of knives on product is achieved without springs, resulting in a uniform contour cut on each ear. Additional features include an in-motion adjusting screw for manually setting the opening of the knives while the machine is in operation, 25% fewer parts in the cutter head, an automatic lubricating system, and a release arm for relieving jams sometimes caused by broken ears or ears trimmed too short. Write Food Machinery and Chemical Corp., Canning Machinery Division, 103 E. Maple St., Hoopeston, Ill., or P. O. Box 1120, San Jose 8, Calif.

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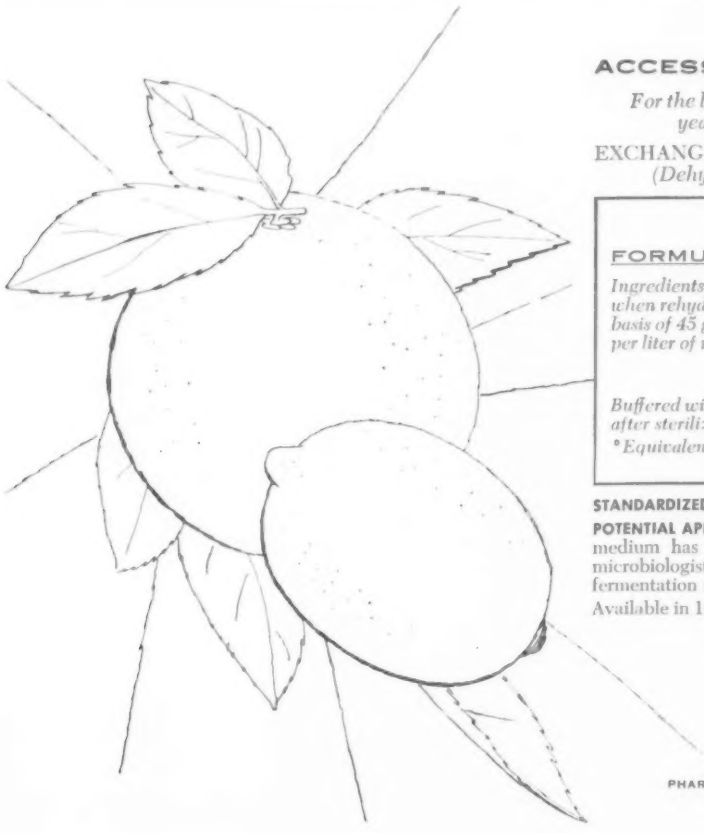
A new direct-operated water pressure reducing valve has been introduced by Spence Engineering Co.,



ACCESSORY NUTRIENT FACTORS

For the luxuriant growth of all lactic acid bacteria yeasts and molds assured by the use of

EXCHANGE BRAND ORANGE SERUM AGAR #77

(Dehydrated) a Complete Culture Medium

FORMULA *Ingredients— when rehydrated on basis of 45 grams per liter of medium.*		
	Orange juice serum solids	12.6g*
	Agar (dry basis)	15g
	Peptone	10g
	Yeast hydrolysate	3g
	Reducing sugars, total	8g
	Sucrose, total	6g
	Cysteine hydrochloride	0.001g

Buffered with 0.2 to 0.6g K_2HPO_4 to provide pH 5.5 ± 0.05 after sterilization.

**Equivalent to 100 ml 12° Brix orange juice serum.*

STANDARDIZED for uniformity and stability.

POTENTIAL APPLICATION—Orange Serum Agar as an all-purpose medium has a wide application to the bacteriologist and microbiologist in the milk, fruit pickling, food, bottling and fermentation industries.

Available in 1 lb. bottles through your laboratory supply house.

Sunkist Growers

PRODUCTS DEPARTMENT

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Inc., Walden, N. Y. Called the D25, the valve can regulate water flow to such fast-acting equipment as flushometers and snap cocks. It incorporates a high-pressure molded diaphragm and heavy spring chamber construction for operation in the reduced pressure range between 30 psi and 80 psi. It is designed especially for dead-end water service where flow is intermittent and subject to abrupt fluctuations. A similar but earlier model, the D24, is recommended for service in a pressure range between 10 and 50 psi.

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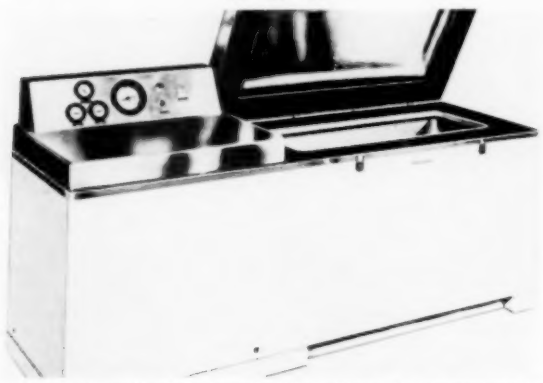

New 1956 models of horizontal utility cabinets for temperatures to minus 120° F., and in 3, 6, and 9 cu. ft. capacities are announced by Hudson Bay Co., Division of Labline, Inc., 3070-82 W. Grand Ave., Chicago 22, Ill. All have two stages of refrigeration, utilizing Freon refrigerant with built-in pressure relief devices and safety controls. Instrument panel includes adjustable thermostat, suction and pressure gauges, pilot lights, and control switches. Interiors are welded 18-8 stainless steel, and may be operated wet or dry. The cabinets are self-contained packaged units, ready for water and electrical connections. The firm also announces its 1956 line of vertical low temperature storage cabinets in 22 and 24 cu. ft. sizes and in five temperature ranges from minus 10° F. to minus 120° F.

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Canners who would like to run several grades of their product through the same cooker at the same time may do so with a **new electronic "marked-can sorter"** which separates the cans as they are discharged from the cooker and sends the mixed cook automatically to multiple labeling and/or casing lines. Each sorting machine simultaneously directs as many as six mixed grades or products, the secret lying in the detection, electronically, of a mark applied by a device of unusual simplicity. Write for details to Dudley Machinery Corp., Santa Clara, Calif.

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Completely redesigned models of Rockwell Manufacturing Company's line of strainers and air eliminators for use with liquid meters offer new "straight-through" flow, greater ruggedness, and increased versatility. Chief advantages of the new strainers, available in both in-line and angle models, are larger screening area and new double-basket construction which protects the inner screen from being stretched or distorted by fast-moving large particles. Chief advantages of the new air eliminators, available with steel bodies in screw and flanged models, include easy access to all working parts, in-line outlet and inlet connections, replaceable valve faces and seats, resilient facing protecting the main and pilot valve assemblies, and toggle-type float arm to the pilot valve linkage. The new models—the "763" strainer and "764" air eliminator—are described in Bulletin OG-326. Write Meter and Valve Division, Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.

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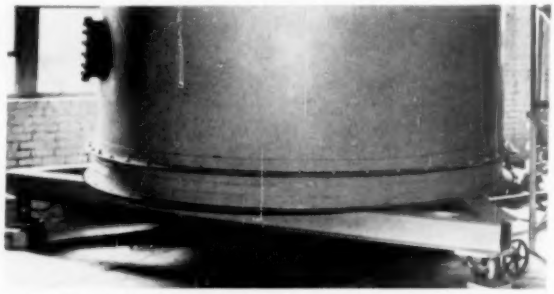

Gauging of this 10,000-gallon liquid sugar storage tank (bottom portion shown above) electrically by weight at the Betteravia, Calif., plant of Union Sugar Division of Consolidated Foods Corporation permits metering liquid sugar into tank trucks without weighing the trucks before and after loading, and gives a constant check on inventory. Baldwin SR-4 load cells of 50,000 pounds capacity each under the corners of the triangular supporting frame are electrically connected with the same Baldwin load indicator-controller as that used for the mixing tank on the floor above. The mixing operation is automatic to the extent of shutting off the flow of dry sugar and water when the desired proportions of each are reached. This is done by the controller when a predetermined weight has been signaled by the load cells under the mixer tank. Both of these valves are opened manually to start the flow of dry sugar and water. Write Baldwin-Lima-Hamilton Corporation, c/o Ketchum, MacLeod & Grove, Inc., 411 Seventh Ave., Pittsburgh 19, Pa.

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Several new construction features are available on **small glass-lined reactors** offered by The Pfaudler Co., 1000 West Ave., Rochester, N. Y. The new "P" series reactors, ranging from five to 100 gallons in capacity, can have a pressure lubricator for seals, or they can be constructed for high pressure work with standardized parts. The high pressure units are rated at 150 psi. In addition, Pfaudler's new hydraulic or air motor drive is available for use on these reactors. Standard, low pressure units in this series are rated for 25 to 30 psi internal pressure. Because the basic design of "P" series reactors is similar to larger vessels, parallel results may be anticipated in working from laboratory to pilot plant and then going on stream with full scale production. Write for Bulletin 927 on the "P" series reactors, and for data sheet 30 on the hydraulic or air motor drive.

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A new unit called "Aero-Seal Chemixer," specifically designed for the **rapid mixing of chemicals in pilot plant scale procedures,** is offered as a counterpart to their popular 23,000 and 45,000 rpm top drive laboratory homogenizers by E. Machlett & Son, 220 E. 23rd St., New York 10, N. Y. The mixer produces speeds from 100 to 10,000 rpm, and efficiently handles between 100 ml. to four liters of materials by utiliz-

ing the appropriate container. Six Pyrex containers of varying capacity—all deep fluted—are available. The unit is equipped with a specially designed teflon aerosol free cap assembly for containers. Dangerous aerosols are contained, while mixing and outside impurities are kept out.

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Series 5000 piloted regulators, intended primarily for remote setting of controllers, pneumatic gauging applications and laboratory use, reportedly are the first instruments to combine great accuracy with small size and simple functional design. The new pressure controllers are virtually primary standards of measurement. They do not drift during the day, and change in control point due to periodic shutdown is negligible. The regulators presently are available in 25 and 60 psi standard ranges, for $\frac{1}{8}$" and $\frac{1}{4}$" pipe sizes. Units are supplied with a single $\frac{1}{4}$" NPT tap for a gauge. Despite low cost and small physical dimensions (just over 2" across flat surface), the controls provide a flow capacity exceeding 6 cfm. Flow curves, specifications, and engineering data available from Governaire Division, Bellofram Corp., Burlington, Mass.

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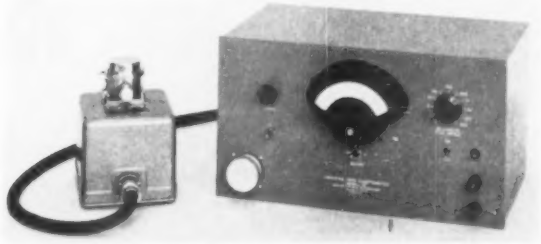

New Model 31 Vibrating Reed Electrometer, with standard ranges of 1, 3, 10, 30, 100, 300, 1000 mv, and 3, 10, and 30 volts, is announced by Applied Physics Corp., 362 W. Colorado St., Pasadena, Calif. The unit is capable of detecting a current as small as 1.0×10^{-17} amperes originating in a high impedance source. Charges as small as 5×10^{-17} and voltages as small as .02 mv can be detected. Radioactivity measurements, C^{14}, H^3, S^{35} determination, pH determination, mass spectrometry, and measurement of electrical properties are a few of the applications for which this instrument can be used.

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A protective lining material for the inside of steel shipping containers soon will be made by another of the nation's largest manufacturers of paint and varnish, according to announcement from the Steel Shipping Container Institute, whose members own Synthetasine Protective Coatings, Inc. Licensing arrangements have been completed with Cook Paint & Varnish Company of Kansas City, Mo., and the firm will supply protective lining formulations for containers ranging from tin cans to 55-gallon drums used widely in the chemical, petroleum, and food industries. The new material to be made by Cook for the steel container industry is much the same in concept as the coatings used on the inside of cans. Linings of this type have greatly expanded the uses for steel shipping containers since they permit shipping products previously considered difficult or impossible to ship in steel. Other manufacturers producing the container linings are Interchemical Corp., New York City; Pittsburgh Plate Glass Co., Pittsburgh, Pa.; and Stoner-Mudge, Inc., Pittsburgh.

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YOUR GUARANTEE
OF MATCHLESS QUALITY,
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Behind the symbol of the Retort stands three generations of family pride and "know-how" in Essential Aromatics, natural and synthetic flavors, perfumer's specialties. Made in the West's most modern plant. The Retort is your guide to dependability.
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An automatic, centralized lubrication system on high-speed, automatic bacon-wrapping machines manufactured by Globe Company of Chicago provides continuous controlled lubrication for 46 key bearing parts formerly lubricated by hand. The lubricators were designed and manufactured by Bijur Lubricating Corp., Rochelle Park, N. J.

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Fully automatic remote control of one or a group of electric motors now is possible with a Rietz unit priced under $200. The device, called the "Loadtrol," will function on motors from five to 150 hp, 220 or 440 volts. Activated by either an overload or underload current signal, it responds instantaneously on both the stop and start function. A variety of completely automatic functions may be assigned the unit. One is motor protection to eliminate hazards to motors forced to labor under overload or underload conditions. Another is to insure continuous full capacity operation of feeders and similar equipment, by per-

mitting motor operation only during periods of optimum load. Other applications reportedly are limited only by the control problems and the technical ingenuity of plant engineers. Write Rietz Mfg. Co., Santa Rosa, Calif.

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A new addition to its line of analytical instruments under the name of CHROMACON is announced by Podbielniak, Inc., 341 E. Ohio St., Chicago 11, Ill. The unit (center and right above) is available separately or in combination with either the firm's THERMOCON automatic recording low-temperature apparatus (at left), or the HYPER-CAL automatic recording high-temperature analytical distillation apparatus (at right). The CHROMACON is a simple and rapid analytical method for gases and liquids used for primary analysis where its accuracy, ranging from one to four percent of component, is adequate. It is a supplement to distillation methods in resolving fractions not separable by distillation alone, and a logical addition to the Podbielniak low and high-temperature methods of fractional distillation. The company offers an exchange plan to Podbielniak users interested in turning in their older models of either the low or high-temperature apparatus as a credit towards purchase either of the latest type THERMOCON or HYPER-CAL, combined with the CHROMACON, as illustrated. Such exchanges are dependent upon age of apparatus, its condition, and general history.

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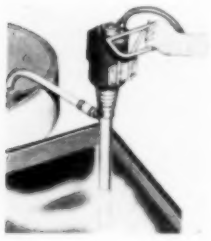

A new portable electric acid pump which conveniently and safely transfers acids from open vessels as well as from standard carboys and drums is announced by General Scientific Equipment Co., 2700 W. Huntingdon St., Philadelphia 32, Pa. The Centri-F Pump is completely self-draining. Rate of flow is approximately six gallons a minute. Self-priming and lightweight, the pump easily is positioned and operated by one man. Pump is furnished in materials suitable for the particular acid service specified.

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Sure-Foot, a **non-slip, abrasive floor coating,** is adaptable to any footing—inside or out—on plant premises, equipment, machinery, or manufactured products. It applies easily and quickly to any surface —wood, concrete, or metal—providing a long-lasting abrasive coating. The product comes in five colors. For details, write Frost Paint and Oil Corporation, c/o Alfred Colle Co., 2446 Park Ave., Minneapolis 4, Minn.

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Production of the first completely sanitary, stainless steel model of the famous Cesco Sausage Trap is announced by Cesco, 4025 Sebastopol Rd., Santa Rosa, Calif. Alnico permanent magnets completely encased in stainless steel make up the working portion of the unit. White Neoprene outer casing, fitted with adapters for installation on the sausage stuffer, between the stuffing valve and the stuffing horn, complete the trap. Traps are available in two models: Model 19088 for fine grinds and emulsions, and Model 19588 for coarse grinds such as salami. Write for Bulletin 191.

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Purity of chemicals in manufacturing, molecular weight, any temperature difference between a reference and variable or between two variables, and calorimetric temperatures can be determined to a precision of 0.001C°, in the range of minus 50° to plus 200° C. with the new Fiske Differential Thermometer, available in either one-element or two-element models. One element measures difference from a fixed reference, and the two-detector system can be used for variables or for sliding differences. Very small 0.2 ml. samples can be checked or monitored. The thermometer's response time is fast. Output can be remotely recorded. For further information, send specifications of your problem to Advanced Instruments, Inc., Needham 92, Mass.

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A new, lightweight scaffolding, manufactured by Waco Mfg. Co., 3555 Wooddale Ave., Minneapolis 26, Minn., is rated at 50 pounds a square foot. The scaffold frames, 4′ high by 4′ wide, feature the "Speedlock" method of attaching braces, and built-in ladders. Braces are the tubular, pivoted type, and a section of scaffold 4′ high, 4′ wide, and 7′ long consists of only four parts. Both frames and braces are made of high carbon steel tubing. A complete line of accessories is available, and rolling towers can easily be made by the addition of casters offered by Waco.

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A new creamery hose announced by Thermoid Co., Trenton, N. J., and known as "Dari-Preen Creamery Hose," is available in five sizes from ½″ to 1½″ ID, and can be supplied with either capped ends or with a tapered nozzle. The white cover is compounded of

NOW AVAILABLE

A revised edition of **Information and Suggestions for Authors** was issued in January 1956. Copies are available to prospective authors of **Food Technology** or **Food Research** papers by applying to

THE EDITOR

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ILLINOIS

The 1956 Institute Directory is available to members at $2.00 per copy. Order from Institute of Food Technologists, 176 West Adams Street, Chicago 3, Illinois.

synthetic rubber highly resistant to butter, animal fats, fish, and animal oils. The tube is specially compounded to carry super heated water under continuous operating conditions. Working pressures range from 100 to 200 psi, depending upon size. The hose, with extra-heavy cotton ply reinforcement, weighs from 43 to 93 lb per 100 ft. Also available on special order with a black cover. Write the firm c/o Harry W. Smith Inc., 41 E. 42nd St., New York 17, N. Y.

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A new line of industrial conveyors introduced by The Colson Corp., Elyria, O., enables the firm to offer completely integrated material handling systems for almost any handling problem. For the present, the line includes skate wheel and roller type gravity conveyors, and expanding and portable powered belt conveyors. Entry of Colson into the conveyor business follows the firm's acquisition of the assets of Service Caster and Truck Corp., Albion, Mich. The addition of Service added powered material handling and lifting equipment to Colson's line of hand-operated equipment.

. . . *the literary corner*

"For many, many centuries, the question of olfactory sensitivity has been left, largely, to the relatively few perfumers and pharmacologists of the ages. Odor was chiefly employed either in the making of cosmetics and perfumery . . . or to the opposite extreme, making an ancient remedy so unpleasant to sniff that it must needs become therapeutic! Today, however, the Age of Science has begun to delve into the mystery of odor for many practical as well as esthetic reasons . . . Thus "Operation Sniff" has been launched . . . as an all-out research attack that makes of the venerable nose a new frontier. Both university and industrial laboratories from coast to coast are trying to find what makes one substance smell different from another . . . and to assist them in their endeavors have developed some unique and bizarre mechanical helpers." Thus begins the excellent article bearing the title of "Operation Sniff," and appearing in the January 1956 issue of *D&O News*, published by Dodge & Olcott, Inc., 180 Varick St., New York 14, N. Y.

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"Logical Design of Digital Computing and Control Circuits with 3C-PACs," 20 pages, is available without charge from Computer Control Co., Inc., 92 Broad St., Wellesley 57, Mass., and 10966 LeConte Ave., Westwood Village, Calif. Examples of the application of 3C-PACs in the design of digital computing and control circuits are given. 3C-PAC operations are related to their symbolic logic equivalents, and a chart method is used that has been found helpful in logical design. The 16-page report "Symbolic Logic, Binary Calculation, and 3C-PACs" by Robert W. Brooks, also is available from the firm.

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Wheelabrator Corp., 1095 S. Byrkit St., Mishawaka, Ind., offers Bulletin 551-D on control of dust from coal handling operations by use of local exhaust ventilation and cloth-tube-type dust collectors. This method is applicable to conveying and preparation of coal for burning in industrial plant or power plant furnaces and boilers; conveying, screening, and weighing of coke for charging foundry cupolas; and conveying, screening, crushing, weighing, and batching of coal in chemical processing.

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The advantages of continuous separation for the food processor are illustrated in a new 4-page bulletin issued by Merco Centrifugal Co., 150 Green St., San Francisco 11, Calif. Flow diagram illustrates operation of Merco units, incorporating the exclusive Merco Return Flow principle which insures a uniform output by preventing a build-up of stagnant solids at the rotor's periphery. Chart shows how Merco units accomplish any one of five basic food processing separations: classification, concentration, clarification, washing and soluble recovery.

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Simple, fast, and economical installation in walk-in coolers is a feature of the self-contained packaged refrigeration unit described in 2-page catalog sheet issued by Nor-Lake, Inc., Hudson, Wis. The literature describes the Plug-In Panel, complete with photos, cutaway drawings, installation instructions, and specifications. The refrigeration units come in five models for every cooler size, reportedly giving dependable, efficient performance without costly breakdowns or dehydration.

LOOK TO TWITCHELL FOR
POWDERED
CARAMEL
COLOR

First introduced over 10 years ago, Twitchell's Caramel Color is now used by leading food manufacturers throughout the country. It is a clean, natural coloring, completely make from dextrose. Twitchell's Caramel Color is particularly suited for use in dry food preparations to produce a rich color, from a light tan to dark brown.

Typical Uses
• Powdered Desserts • Dehydrated Soups
• Dry Cake Mixes • Bouillon Powders
• Powdered Coffee and other beverages
• Powdered Gravy Seasonings

Write for Sample!

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CRESTMONT & HADDON AVES. • CAMDEN 4, N.J.

Information Bulletin, December 15, 1955, published by The Refrigeration Research Foundation, 200 Midland Bldg., Colorado Springs, Colo., offers free reprints of an article appearing in *Food Technology* for November 1955. The article, by C. Olin Ball, analyzes the facts that bear on the relationship of so-called "cold" sterilization to the canning industry.

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Fatty Acid News Digest for December 1955, published by Fatty Acid Division, Assn. of American Soap & Glycerine Producers, Inc., 295 Madison Ave., New York 17, N. Y., notes the availability of the Eighth Edition of the *Official Methods of Analysis of the Association of Official Agricultural Chemists*, 1008 pages, price $12.00. Included is an important new chapter on spectrographic methods. Write Assn. of Official Agricultural Chemists, P. O. Box 540, Benjamin Franklin Station, Washington 4, D. C.

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Two new booklets are available from the Can Division of Crown Cork & Seal Co., 9300 Ashton Rd., Philadelphia, Pa. The booklet on "F" style cans describes how they stack tightly, improving displays and giving savings in storage, shipping, filling, and handling. The new design has the nozzle in center of top, and the bottoms have a drawn recess which registers on the nozzle of the supporting can when stacked. The processes in the development of label art and "motivation design" are discussed in detail in a booklet on art design and lithography also available from the Can Division.

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"The New L. A. Line of Electric Motors" is the title of an informative bulletin published by The Louis Allis Co., Milwaukee 7, Wis. The brochure includes photos and information on the firm's new open drip-proof, as well as enclosed and explosion-proof, electric motors, manufactured to the new NEMA standards. Write the firm c/o Hoffman & York, Inc., Century Bldg., Milwaukee 3, Wis.

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Practical information on the nutritional values present in meat is included in an address, "Eating for Fun and Health," delivered recently by Dr. B. S. Schweigert, assistant director of research and chief of the Division of Biochemistry and Nutrition at the American Meat Institute Foundation, and available as Foundation Circular No. 17. Write the Foundation at 939 E. 57th St., Chicago 37, Ill.

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A standard for designation of turbidity or "cloud" in citrus juices is proposed in a recent publication by research workers of the Southern Utilization Research Branch, USDA. Since partial loss of cloud is considered one of the first indications of deterioration in citrus juices, such a standard should be useful to graders, processors, and handlers of such juices, particularly frozen concentrates. Details of the method employed with transmittance tables, bentonite equivalents of colorimeter dial divisions, and designation of cloud values in terms of bentonite are given in the publication, ARS-72-8, "A Proposed Standard for Designation of 'Cloud' in Citrus Juices." For free copies, write Southern Regional Research Laboratory, 2100 Robert E. Lee Blvd., New Orleans 19, La., or the U. S. Citrus Products Station, Winter Haven, Fla. From the former address also is available a free reprint covering the acetone-hexane winterization of cottonseed and peanut oils, entitled "Acetone-Hexane Mixture as Related to Reduction in Refining Loss and Color," publication 85-15.

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Design, engineering, construction, and initial operation of process industries plants by the Chemical Plants Division of Blaw-Knox Company, Farmers Bank Bldg., Pittsburgh, Pa., are outlined in Bulletin 2514, entitled "Process Plants by Blaw-Knox." Illustrated with photographs of major projects, the brochure is designed to provide information on the diversity and scope of work undertaken and completed in the process industries field, including the food processing industry. Write for free copy.

. . . *meeting hall and conference room*

At the annual Christmas Party of Givaudan-Delawanna, Inc., held at the Swiss Chalet, Rochelle Park, N. J., six employees were presented with gold Swiss watches to celebrate their 25th anniversary with the flavor firm. The six new 25-year veterans, who brought the total number to 63, are, from left: Dr. Max Luthy, vice president of production and research; Mr. Jos. Balsam, Miss Louise Lehman, Mr. Edwin P. Nicholson, Mr. Wm. Wisse, and Miss Ellen Stapleton. Mr. E. R. Durrer, Company president (second from right), makes the presentation, while Mr. R. E. Horsey (far right), vice president in charge of sales, looks on.

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All roads lead to Boston for at least two conventioning groups in the food field. On April 11-13, the Research and Development Associates, Food and Container Institute, Inc., will hold its Ninth Annual Meeting which also will be a celebration of the tenth anniversary of the organization's founding. Highlights of the three-day meeting include addresses by The Quartermaster General of the Army and other prominent military and industry figures, discussions on radiation preservation of foods, and a full day's guided tour of the new $11 million Quartermaster Research and Development Center, located at nearby Natick, Mass. Inquiries should be directed to Col. Rohland A. Isker, secretary, Research and Development Associates, 1819 W. Pershing Rd., Chicago 9, Ill.

Two months later, June 10-14, Boston will play host to the 73rd Annual Convention of the National Confectioners' Association and the concurrently held 30th Annual Confectionery Industries Exposition. General Convention Chairman is Mr. Robert H. W.

Welch, Jr., of James O. Welch Company, and the Exposition Committee is under the chairmanship of Mr. David P. O'Connor of Penniek and Ford Ltd., Inc. For information on Convention or Exposition write NCA headquarters, Suite 426, 221 N. LaSalle St., Chicago 1, Ill.

. . . *building up and branching out*

Sheffield Chemical Co., Inc., Norwich, N. Y., became a separate operating division of Sheffield Farms Co., Inc., as of January 1, 1956, and will be known as Sheffield Chemical, Division of Sheffield Farms Company, Inc. The latter is a subsidiary of National Dairy Products Corp. Sheffield Chemical, whose main office remains in Norwich, will continue to produce and sell products derived from milk, with emphasis on highly refined and edible items for pharmaceutical, food, and biochemical applications. Mr. John R. Borst, who was vice president of the Chemical Company, becomes general manager of the new Division. Mr. F. A. Baldauski, formerly technical director of the subsidiary company, has been appointed sales manager, and Mr. G. C. Hooks, technical director of Sheffield Chemical. Mr. P. M. Reed and Mr. A. A. Sullivan also have been appointed production manager and operations manager respectively of the new Division.

The men who launched the Spinco Division of Beckman Instruments, Inc.—Mr. Maurice Hanafin, left, general maneger, and Dr. Edw. G. Pickels, research director—discuss the Belmont, Calif., instrument firm's latest development, a continuous flow electrophoresis unit used to prepare rare chemicals in pure form for laboratory use. Tell-tale traces left by substance as it was separated electrically into its components are indicated by Dr. Pickels. Rare toxins, certain hormones, proteins, and enzymes can be collected in pure state with latest Spinco instrument. Spinco Division has begun construction of a modern $500,000, 33,000 sq. ft. research and development center for specialized medical instrumentation on a 5-acre site at Stanford Industrial Park.

Wm. J. Stange Co., 342 N. Western Ave., Chicago, Ill., announce an extensive expansion program under way, including establishment of new manufacturing plants in Paterson, N. J., and Mexico City, Mexico, a new building for Stange-Pemberton, Ltd. in New Toronto, Canada, which will triple present plant capacity, and an expansion which will double the size of the present Stange West Coast manufacturing branch in Oakland, Calif.

Twenty-one new sales engineers have been added to the field sales force of Minneapolis-Honeywell Regulator Company's Industrial Division, it was announced by Mr. J. A. Robinson, field sales manager. They were assigned to 19 branch offices located in 18 U. S. cities and one Canadian city. The new sales engineers are all graduates of the Division's training school's twentieth anniversary class.

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Customer service and high standards of production keynote the operation of the new bulk corn syrup station recently opened by The Hubinger Company, Keokuk, Iowa, manufacturers of OK Brand Corn Syrups and Starches, at St. Johnsville, N. Y. The company's new facility is the first modern syrup filling station in the central New York State area, and is located adjacent to the east-west route of the N. Y. Central R. R. in beautiful Mohawk Valley. The new Hubinger station is a former modern milk plant ideally suited to bulk corn syrup handling, with enclosed filling docks for corn syrup tank wagons and adequate space for processing, storage, and conveying equipment.

Semet-Solvay Petrochemical Division, Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y., announces appointment of the L. H. Butcher Company of San Francisco to handle sales and technical service for A-C Polyethylene in Washington, Oregon, Utah, Colorado, Idaho, New Mexico, Nevada, and

Arizona. The Butcher Company maintains sales offices and warehouses in San Francisco, Los Angeles, Seattle, Portland, and Salt Lake City.

In line with his firm's expansion of sales in America and abroad, Mr. Alan Katz, executive of F. Ritter & Company of Los Angeles, manufacturers of essential oils and aromatics, is establishing sales agencies in the Philippines, Japan, Australia, Hong Kong, and other free ports outside the influence of Red China. He will be gone for a period of about four months, and expects to cover as much as 100,000 miles. Another company executive, Mr. Leonard Katz, has returned from a two-months trip to South America, made for the same purpose.

Beckman Ratio-Recording Spectrophotometer Model DX-1 (strip-chart recording) and DK-2 (flat-chart recording) now are available for inspection in a new display room at the offices of Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago. Chemists are invited to make an appointment for a demonstration and bring samples for running analyses.

A powerful source of radioactivity was installed at the General Mills Research Laboratories, Minneapolis, on 17 January to be used in studies of chemicals and food irradiation. The source, nearly 4,000 curies of high activity cobalt 60, is the only major cobalt source in the area and one of the largest in the country. Its radiation energy is equivalent to about 6,000 grams of radium, which would be worth about $120 million —far more radium than ever has been isolated in the world.

New building of High Voltage Engineering Corp., 7 University Rd., Cambridge 38, Mass., makers of supervoltage particle accelerators for chemical processing, therapy, radiography, and research, will contain the world's largest radiation machine test facility. The 88,000 sq. ft. structure, located on a 50-acre tract in Burlington, Mass., is expected to be ready for occupancy in September 1956.

Appointment of Biochemical Procedures, 8350 Wilshire Blvd., Beverly Hills, Calif., as West Coast Laboratory of Foster D. Snell, Inc., New York City firm of consulting chemists and engineers, was announced by Dr. Foster D. Snell, president and board chairman. Mr. S. Louis Gaines will head the West Coast Snell operation, fourth new installation opened by Foster D. Snell, Inc., in recent years.

Truesdail Laboratories, Inc., Los Angeles, has established an operating division laboratory in Honolulu, and arrangements have been made to lease space in a new building soon to be erected by Hawaii Chemical Co., Ltd., according to Dr. Roger W. Truesdail, president. The new Honolulu division will render applied laboratory services, with certain highly technical problems to be handled by the staff and specialized equipment in the Los Angeles headquarters.

. . . *the human element*

Mr. Alfred A. Mulliken, IFT member, has joined the staff of the Chemical Specialties Manufacurers' Association as assistant secretary. The position is a new one, created by the trade association to serve increasing needs of its members in the aerosol, automotive specialties, disinfectant and sanitizer, insecticide, soad, detergents, sanitary products, floor wax, and floor finishes industries. Mr. Mulliken will directly assist **Mr. H. W. Hamilton,** who has served for the last 15 years as secretary and managing director. For the last seven years, Mr. Mulliken has been associated with The Creamery Package Mfg. Co.

Mr. Norbert H. Volle, IFT member, has been transferred from general production superintendent of the Cincinnati Manufacturing Division of The Kroger Company to manager of the newly created Department of Product Development and Research in Kroger's Processed Foods Division.

. . . new R&D responsibilities for Kroger's Volle

Mr. J. E. Meihuizen, managing director of Polak's Frutal Works NV., Amersfoort, Holland, visited the flavor firm's head offices in Middletown, N. Y., early in December.

Dr. Robert P. Joslin, member of IFT, formerly senior research chemist for Monsanto Chemical Co., has been appointed product research manager for Fairmont Foods Co., 3201 Farnam, Omaha, Nebr. Announcement of the appointment was made by Fairmont President John A. Robins. Dr. Joslin received his doctorate in food technology from MIT and, prior to his work with Monsanto, was engaged in research work at that institution for approximately seven years.

. . . from Monsanto to Fairmont for Joslin

Mr. Vincent V. Tivy, formerly manager of refinery instrument sales for The Foxboro Company, Foxboro, Mass., recently was appointed the firm's chief application engineer, responsible for coordinating sales engineering with product development and production engineering activities. He also will serve on Foxboro's Engineering Executive and Sales Product Committees. The firm also announces the following new sales office appointments, augmenting instrument sales engineering service in the growing industrial areas of the Southeast: **Mr. E. W. Prendergast,** formerly branch manager at Atlanta, to regional manager of the Southeast territory; **Mr. R. F. Suttoa,** formerly of the Pittsburgh sales office, to industrial engineer at Pensacola, Fla.; **Mr. F. J. Stevens, Jr.,** to industrial engineer at Lakeland, Fla.; **Mr. H. C. Craig** to branch

manager at Jacksonville, Fla.; **Mr. L. C. Estes** to industrial engineer at Atlanta; **Mr. G. W. Reed, Jr.,** to manager of the New Orleans office; and **Mr. J. K. Younkins** to manager at Charleston, W. Va. Joining the company as industrial engineers were **W. H. Rhyne, T. A. Jones, and M. N. Walker** who will be assigned to the Chattanooga, Charlotte, and Knoxville offices respectively.

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. . . a salty assignment for Klomparens

Mr. Karl Klomparens, IFT member, has been appointed technical director for the Diamond Crystal Salt Company of St. Clair, Mich. He will be in charge of research and product development, and also will act as technical advisor to customers on industrial problems. As assistant editor of *Food Processing* magazine for the past 2½ years, he has written many articles on new food processes, techniques, and products. He holds an M.S. in food technology from Michigan State University.

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Election of **Mr. Ben W. Wilson** as vice president in charge of manufacturing, **Mr. Zenas Block** as vice president in charge of planning and research, and **Mr. F. M. MacGregor** as vice president in charge of purchasing has been announced by Doughnut Corporation of America. During the past five years, the firm has expanded its activities as the world's largest manufacturer of prepared mixes and automatic donut machinery for the baking industry into the consumer frozen food field, the dairy industry, and the processed fish and meat field.

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. . . Continental's new Physicist Erlandson

Dr. Paul Erlandson, former chairman of the physics department and assistant vice president of Southwest Research Institute, San Antonio, Texas, has been named director of the department of physics of Continental Can Company's new Central Research and Engineering Division, according to Mr. Curtis E. Maier, general manager of the division, which ultimately will employ 75 professional scientists and 25 administrative personnel. In his new position, Dr. Erlandson will head the company's experimental work on application of the principles of physics to the high-speed automatic equipment used in manufacturing and closing metal, paper, plastic, and composite containers and closures, as well as to its future ionizing radiation sterilization program.

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In a move enlarging its services, B. Heller & Company, Chicago, has announced creation of two new sales manager posts for its Meat and Institution divisions. Heller manufactures ingredients for food products used by 20,000 customers. **Mr. Auggie R. Ring, Sr.,** who has been district manager for the East and South, has been promoted to sales manager for the entire Meat Division. The position of sales manager for the Institution Division has been placed in the hands of **Mr. Milton A. Cole,** 15-year veteran in institution sales.

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Appointment of **Mr. Stanley P. Dodd** as technical director was announced by Chicago Apparatus Co., 1735 N. Ashland Ave., Chicago. Mr. J. O. Bengston, president, said Mr. Dodd will direct the product development, technical information, and technical services of the firm, one of the nation's leading laboratory supply houses.

. . . technical director's duties for Dodd

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Appointment of **Mr. V. J. Verhunce** as superintendent of manufacture of American Can Company's Central Division was announced by Mr. L. W. Graaskamp, division vice president. Mr. Verhunce, who had been manager of the firm's St. Louis plant since 1952, succeeds **Mr. C. E. Martin,** newly appointed assistant manager of manufacture in Chicago. In his new post, Mr. Verhunce will be concerned with the company's division manufacturing activities embracing 25 states and 23 Canco plants.

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Mr. P. Val. Kolb, 70, president of Sterwin Chemicals Co., 1450 Broadway, New York City, a subsidiary of Sterling Drug, Inc., died December 5 at Rock Hill, S. Carolina. Mr. Kolb was a very well-known figure

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in the chemical industry, and in such allied fields as baking, flour milling, and pharmaceuticals for more than 30 years. He had been associated with Sterwin since 1940. At his death, Mr. Kolb was also president of Sterwin Chemicals of Canada, Ltd.

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The *Fats and Oils Abstract Service*, published by Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., is now under new auspices as regards the editing and abstracting. Scientific editor of the Service will be **Dr. W. O. Lundberg,** executive director of the Hormel Institute and professor of agricultural biochemistry at the University of Minnesota. He will be assisted by a group of abstractors, all members of the Hormel Institute staff, who are experienced in the chemistry and biochemistry of lipids.

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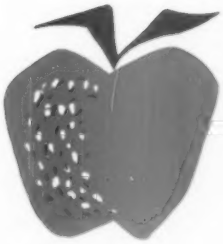

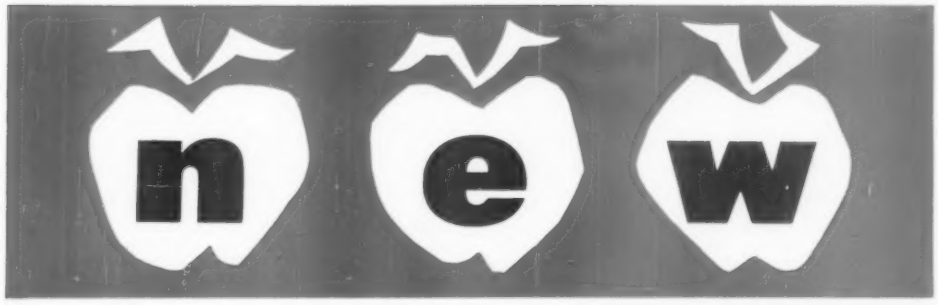

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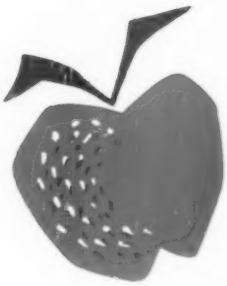

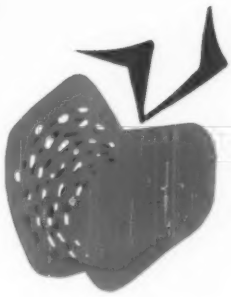

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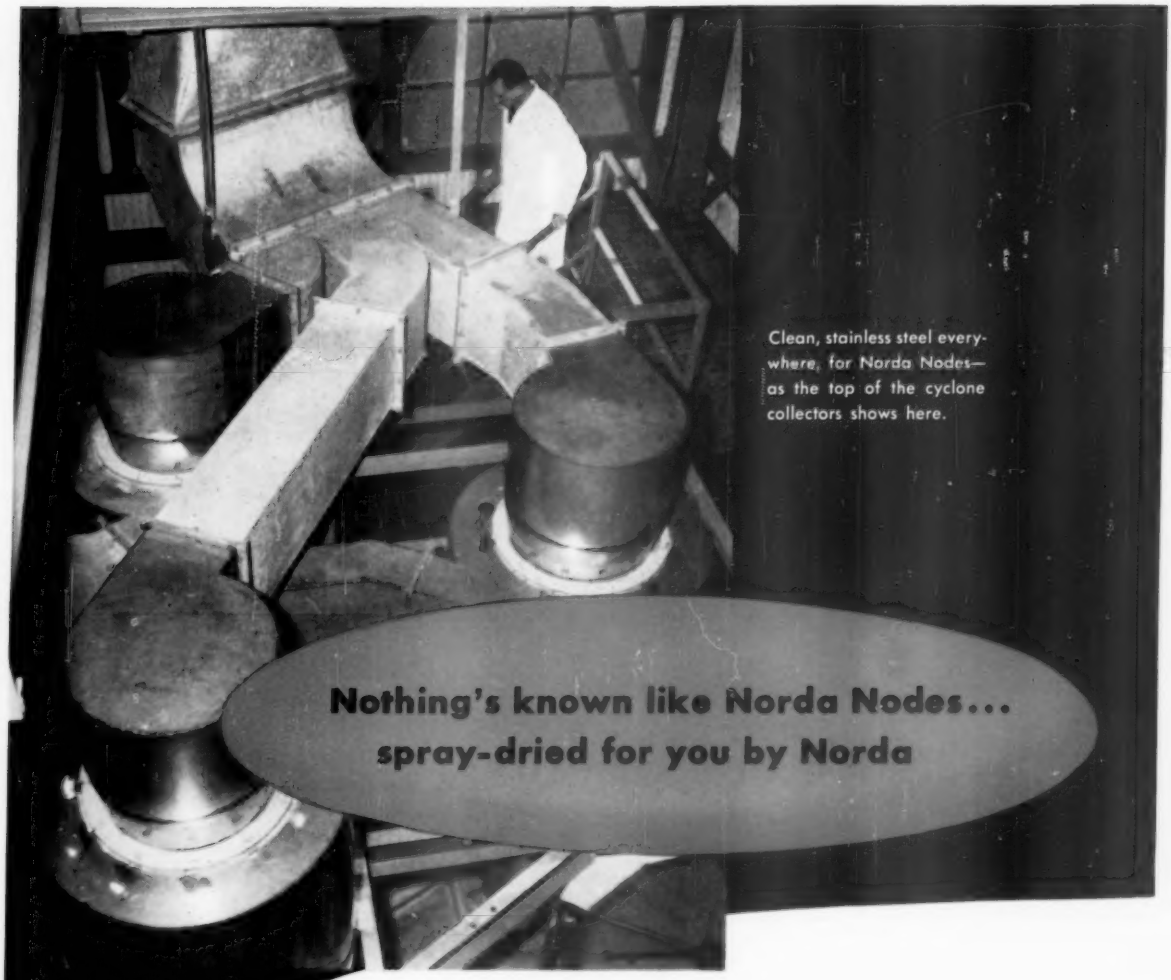

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